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ENGLISH MOVABLE HYDRAULIC CRANE FOR SHIPPING COAL FROM END-TIP OR HOPPER CARS.

MODERN COAL-HOISTING APPARATUS.

MODERN COAL-HOISTING APPARATUS.

By FRANK C. PERKINS.

AT the present time coal is conveyed in large quantities by rail and by sea to various manufacturing plants and power stations, where it is stored for boiler service in high coal bunkers or pockets. Very efficient coal hoisting and handling machinery has come in use on account of the demand for increased speed with this apparatus. At the Lincoln wharf power station of the Boston Elevated Railway Company, a modern equipment has recently been installed by the C. W. Hunt Company, of West New Brighton, which is claimed to be one of the most rapid unloading equipments in use at the present time.

It is very important that the cars and steamships have their large coal cargoes unloaded with the greatest dispatch, as the demurrage amounts to a considerable item, which every economical management desires carefully to avoid. It is claimed that the problem involved in these cases is more difficult and very different from that of bulk unloading and storage of coal on the ground level from the vessels or cars. The accompanying illustrations show the coal-hoisting towers at the Lincoln plant, as well as the main hoisting and trolley engines and automatic duplex two-ton shovels utilized for this purpose. The piping is arranged with Moran flexible steam-pipe connections, which permit each tower to travel 15 feet in either direction without breaking joints. The engines employed have a capacity of 300 horse-power, which is three or four times the output usually developed. With this equipment the bituminous coal was raised from one hatch of a vessel and delivered to the storage pockets 90 feet above tide water at the rate of 640,000 pounds per hour, using one tower, while usually a single tower has an ordinary speed of 40 to 50 tons per hour and a maximum speed of 100 tons per hour, hoisting the coal to a height of about 50 feet above tide water.

A coal-cracking machine is used for breaking the coal to proper dimensions for automatic stokers before passing to the pocket, and handles over 10,000 pounds per minute. The coal is delivered to the coal-cracking machines by the hoisting machinery by automatic steam shovels having a capacity at each lift of 4,000 pounds. The machinery installed in the coal-hoisting towers is subjected to great shocks, the work being of the severest and hardest kind, as the service changes constantly, in some cases soft pea coal being unloaded from open wooden barges, while in other cases large cubes of hard foreign coal being unloaded from steel vessels with very small hatches. With the equipment of the Boston Elevated Railway car station it has been possible to raise two tons of coal nearly 100 feet above the hold of the vessel to the discharging hopper in six seconds. The equipment will perform an entire operation, including a round trip of the shovel, in about one-third of a minute. This operation includes the lowering and moving of the shovel out of the boom, digging up 4,000 pounds of coal and raising it to the level of the hopper and discharging it into the same, all within this short period of time.

The Hunt steeple tower for coal hoisting requires two engines and two engineers, one for hoisting the steam shovel and the other for running the trolley in and out on the boom. The steel booms hold up in a vertical plane, thus avoiding any danger of interfering with the shrouds of the vessel. The engines used in this equipment, it will be noted, have a capacity of making nearly three round trips in one minute with a two-ton automatic shovel. The Hunt steeple tower rigs used in this equipment have electrically-driven moving gears and coal crackers, while the hoisting engines are direct connected. The towers have to move 30 feet at a time without changing steam connection, and have to traverse overhead the whole length of the coal storage pocket. Several of these towers can work at the same time, as a single tower can operate on each hatch of the vessel. The boom has an overhang of 40 feet, so that it can operate on coal steamers of the largest dimensions and the widest beam, and works entirely free from the vessels with their rigging, as the boom folds up as mentioned above.

An electrically-driven crane for construction work, using a somewhat similar shovel, is constructed at Karlsruhe, Baden, by the Gesellschaft für Elektrische Industrie. Many engineers claim that the hoisting machinery for this class of work is worked more economically by electric power than by steam or hydraulic power. Among the advantages claimed for the use of electric motors for working this class of hoisting machinery are the small space required as well as the comparatively small weight necessary, with the slight attention required, and the ease with which the electric energy may be transmitted to the hoisting apparatus. The starting and stopping of the motors is so simple that even persons possessing no technical knowledge at all may soon be efficient in attending them. The hoisting machinery actuated by an electric motor is ready for work at any time, and the motor starts very easily. By adjusting the starting apparatus or current regulator, the strength of the current may be diminished or increased; the speed of the motors, therefore, may, if required, be carried within certain limits, and the direction of their rotation altered. The electric hoisting machinery is well adapted for use in central station and at harbor, on account of the convenience in the distribution of power. Portal and semi-portal cranes are frequently preferred on account of their taking up the least room on a wharf, and not even restricting the railway traffic.

The accompanying illustrations show excellent examples of movable quay cranes with large pedestals, having an opening through them of sufficient width and height to allow railway cars and locomotives to pass through them, and have the great advantage of offering very little obstruction to the traffic on the quay. One of the movable hydraulic cranes shown was constructed by Sir W. G. Armstrong, Whitworth & Co., Ltd., of Newcastle-on-Tyne, England, for shipping coal direct from cars, whether of the end-tip or hopper type. These cranes are said to be very convenient for use in connection with a fixed coal hoist, as coal can then be loaded at two hatches at once, and they are especially adapted for shipping bunker coal. Another movable hydraulic hoist for shipping coal was specially designed by Sir W. G. Armstrong, Whitworth & Co., Ltd., to lift from either of two lines of rail running parallel with the quay edge; but the same type with modifications is said to be adapted for sites where the

GENERAL VIEW OF THE HOISTING TOWERS AND THE COAL POCKETS OVER WHICH THEY TRAVEL.

AN ELECTRIC CRANE USED FOR CONSTRUCTION AT KARLSRUHE.

MODERN COAL-HOISTING APPARATUS.

rails approach at right angles to the quay, in which case a fan-shaped arrangement of rails is used, and the hoist is brought up to either of the lines of rail forming the fan which may best suit the ship.

THE RAILROADS OF THE WORLD.

The annual statistics of the Archiv für Eisenbahnwesen giving as near as may be the figures for the end of the year 1902, show the mileage of railroad at that time in each grand division of the world to have been as follows:

Europe	183,997	North America	233,186
Asia	44,358	South America	28,822
Africa	14,554	Australia	16,038
Old World	242,909	New World	278,046

This makes a grand total of 520,955 miles for the whole world, of which 53 1-3 per cent is in the New World and 44¾ per cent in North America.

The additions to the railroads of the world for seven successive years have been, in miles:

1896.	1897.	1898.	1899.	1900.	1901.	1902.
9,796	10,747	10,864	13,533	10,800	16,551	13,338

This gives a total of 85,629 miles for the seven years, being an average of 12,233 miles per year. The average mileage built was greatest from 1880 to 1890, when it was 15,218 per year.

The considerable decrease in construction from 1901 to 1902 was due chiefly to the reduced construction in Asia (4,345 miles in 1901 and 2,535 in 1902) and Africa (1,690 miles in 1901 and 364 in 1902). More was built in America in the latter year than for several years previous; and more than appears from the Archiv's statistics, which takes its figures for the fiscal year ending with June for both Canada and the United States, which together have more than two-fifths of the world's mileage, and where more than two-thirds of the railroad completed in any calendar year is opened in the last half of such year.

The countries of Europe which added most to their railroad mileage in 1902 were:

France.	Germany.	Russia.	Sweden.	Austria Hungary.
619	615	581	366	340

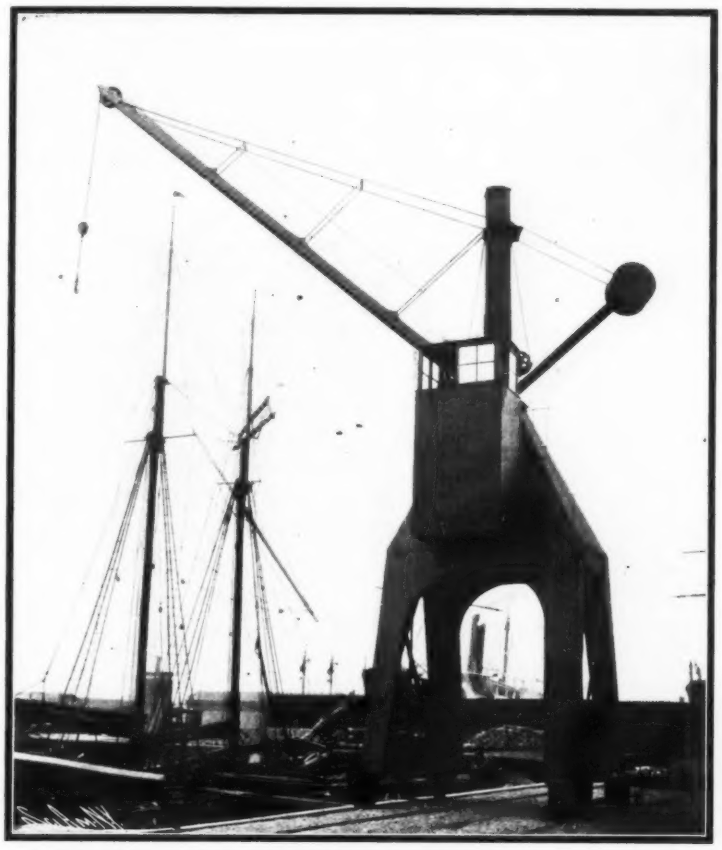
All the rest of Europe built but 664 miles. Russia is credited with no addition to its mileage in Asia in 1902, but 629 miles were opened in India and Ceylon, 165 in Japan, 174 in China, 95 in Siam, and 12 in Korea. The table also includes 1,490 miles in French Cochin China, the larger part of which certainly is not built yet.

The English-speaking peoples maintain their position as the railroad-building race. Of the 520,955 miles of railroad in the world, 270,881 miles are in the United States and in Great Britain and its colonies. The railroad mileage of the British colonies in America, though not one-tenth as much as that of this country, is nearly twice as great as that of any other American country, and Great Britain still has more than three-fifths of the Asiatic railroads, and since 1898 has built a fourth more than Russia in Asia.

The South American countries (with which we have included the West Indies) make haste slowly. They added but 234 miles to their lines in 1902, and but 1,804 miles in the four years then ending. Brazil, that great country, is credited with no addition since 1899, and Argentina, the United States of the southern continent, with none in 1902, and but 406 miles since 1899.

The Archiv für Eisenbahnwesen continues its tables of the capital invested in the railroads of the different countries, which it began a few years ago. Naturally, they are less complete than the statements of mileage; but the mileage for which the figures are not attainable cannot be very important. According to these data, the investments in the railroads of the world amounted at the end of 1902 to the stately sum of $34,964,342,000, of which more than $18,800,000,000 have been spent on the 184,000 miles in Europe and $16,160,000,000 on the 337,000 miles in the rest of the world. This gives an average of $114,760 per mile for the European, and of $57,009 for the Barbarian railroads. The country with the highest capital cost per mile is, of course, Great Britain ($256,839); the nearest approach to it is Belgium ($150,239). The cheapest in Europe are the Finnish State railroads ($32,104); but the private railroads of Sweden are put down at $22,558 per mile. Elsewhere the colony of West Australia has spent but $27,597 per mile for its lines (light, narrow-gage railroads); Japan, $38,320 (also mostly narrow-gage).

The summing up of the acquisitions of the world, all made within the last eighty years, in these instruments of production, results in something like awe. The capital which they represent could not possibly have been obtained in any previous age, and it is safe to say that the improved means of transportation themselves have made possible its accumulation and vastly more. The imagination is lost in efforts to foresee what may be the result in the next eighty years of these and of the other appliances which have so greatly multiplied the productive powers of man.



ARMSTRONG MOVABLE QUAY CRANE WITH LARGE PEDESTALS FOR THE PASSAGE OF LOCOMOTIVES AND CARS.

Typesetting Machines in Germany.—The central commission of machine typesetters of the book-printing trade of Germany gives the following statistics:

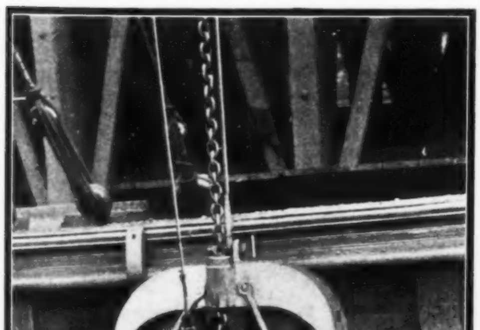
There are 1,023 typesetting machines used by 513 firms, which are scattered throughout Germany, but it is believed that there are in reality 1,040 of these machines in use in Germany.

There are 1,508 persons employed, of whom 1,457 males and 13 females are assistant operators.

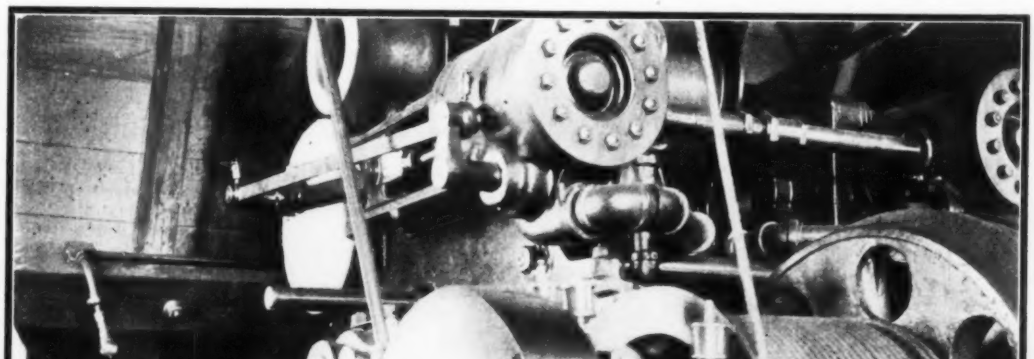
The setters work permanently on the machines from thirty-six to sixty hours a week. The approximate time of working is forty-eight hours a week.

At the minimum tariff rate there are 163 setters employed; above this rate 895 and below this rate 115. Some are paid by the month and receive from $31.65 to $44.03.

It is claimed that about 2,600 typesetters have lost



LOADED BUCKET HOLDING 2 TONS OF COAL, DEPOSITING ITS LOAD IN A POCKET 100 FEET ABOVE THE HOPPER IN 6 SECONDS.



MAIN HOISTING ENGINES OF ARMSTRONG COAL-HOIST.

MODERN COAL-HOISTING APPARATUS.

employment through the increasing use of typesetting machines in this country.

In Leipzig alone 14 printing houses have in use 66 typesetting machines.—Hugh Pitcairn, Consul-General at Hamburg, Germany.

SOME EXPERIMENTS ON AN AIR-COOLED PETROL MOTOR.

By Prof. H. L. Callendar, M.A., LL.D., F.R.S.

Stationary gas and oil engines have long been the subject of elaborate scientific investigations, which

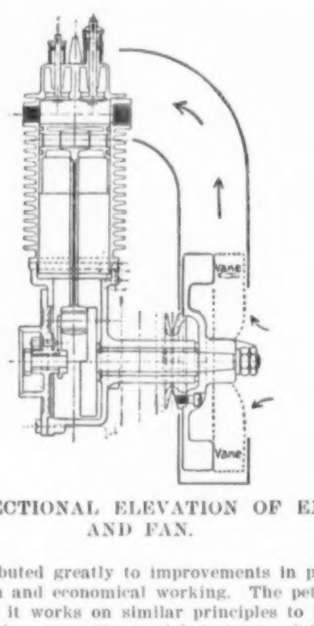


Fig. 1.—SECTIONAL ELEVATION OF ENGINE AND FAN.

have contributed greatly to improvements in practical construction and economical working. The petrol motor, though it works on similar principles to the stationary engine, presents special features of interest, and may well claim its share of attention on account of the important part which it is destined to play in the near future. Scientific experiments on this type of engine are comparatively few; partly because it is of more recent development, and partly because, from the nature of the case, it is more difficult to test satisfactorily under the conditions of use. More particularly is this true of the small air-cooled motors so extensively used for motor cycles. These light motors are perhaps the most interesting, as being the simplest and the most powerful for their weight, and as differing most widely in construction and operation from the stationary engines which have been so carefully studied. At the same time, they are also the most difficult to test, on account of the high speed at which they run, and the rapid variations of temperature to which they are liable. The conditions affecting the distribution of temperature in such a motor are the most important and interesting to study, and afford a good illustration of the application of electrical methods of measuring temperature. In relation to the temperature question, it has also been necessary to make a careful study of the indicator diagram under various conditions of running, in order to obtain some light on the internal temperatures to which the cylinder is exposed, and to investigate the effects of load and speed, of throttling and back-pressure and retarded ignition. It would not be possible, in an article like the present, to give a full scientific discussion of all the experiments, but it is hoped that the present summary, in spite of its incompleteness, may prove interesting and suggestive as a guide to future research.

THE ENGINE.

The engine employed in these experiments is a small Clement-Garrard cycle motor with 60 millimeters bore

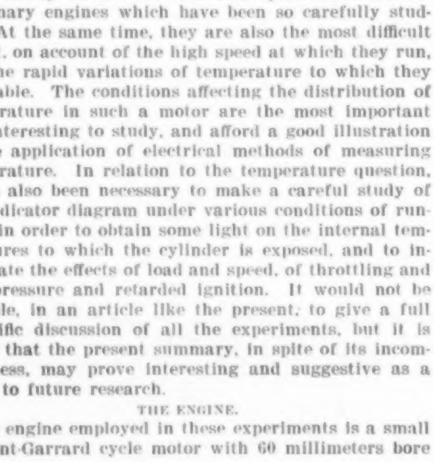


Fig. 2.—INDICATOR DIAGRAMS OF PETROL MOTOR. (CLERK.)

and 70 millimeters stroke, having a cylinder capacity of 198 cubic centimeters, or about 12 cubic inches. The clearance volume is approximately 60 cubic centimeters, or about 3-10 of the stroke. The engine has an external fly-wheel and good long bearings, and is well made, so as to be capable of running at a high speed. The valves are placed on the top of the cylinder, and not in a valve-chamber at the side, which is the more usual method of construction. The position of the valves is shown in the section in Fig. 1. The advantage of having the valves on the top of the cylinder is that the heat of the exhaust is further removed from the working surface of the barrel.

The C. G. engine is much smaller than is usually fitted to a motor cycle, but is very powerful for its size. Before the commencement of the experiments, this particular engine had already driven a cycle with fore-carriage attachment, the total load often exceeding five hundredweight, for a distance of nearly 4,000 miles, at an average speed of 14 to 15 miles per hour in all kinds of weather. Engines with cylinders of double the capacity are generally used for this purpose. In spite of this heavy work, the engine has not required any replacements, and appears to run as well as ever. It was tested with the old valves, etc., in place, as nearly as possible under the ordinary conditions of running, without any special preparation, to get as fair a test as possible of the performance of an engine of this kind when in good average running order. The only alterations made in the accessories were the addition of a cooling fan, illustrated in Fig. 1, to enable the engine to run at low gears for hill climbing; and a variable speed gear for the same object. A slight modification was made in the carbureter, to make the proportions of the gas and air mixture independent of the speed; and a simple arrangement was added to enable the tension of the inlet valve spring to be adjusted while running for experimental purposes.

The engine, like most other internal combustion engines, works on the Beau de Rochas, or four-stroke cycle of operations. (1) Suction.—An explosive mixture of air and petrol vapor, formed in the carbureter, is sucked into the cylinder on the down stroke of the piston through the inlet valve, which closes on the completion of the down stroke. (2) Compression.—The mixture is compressed during the next upstroke of the piston into the clearance volume in the cylinder head. (3) Explosion.—The compressed mixture is ignited when the piston is near the top of its stroke, and the increase of pressure due to the explosion drives the piston forward with a much greater force than was required to compress the mixture in the compression stroke. (4) Exhaust.—The exhaust valve is opened near the end of the explosion stroke, and the burnt gases are expelled through a silencer during the return stroke of the piston. The exhaust valve closes at the end of the stroke, and the cycle of operations then recommences.

THE INDICATOR OR MANOGRAPH.

For the purposes of this investigation, a special type of indicator was employed in order to obtain trust-

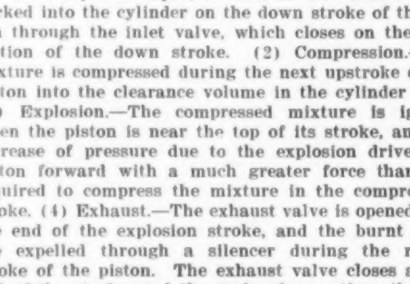


Fig. 3.—DIAGRAM OF INDICATOR OR MANOGRAPH.

worthy results at high speeds. The indicator of the ordinary type employed in steam engine or gas engine work at moderate speeds (up to, say, 500 revolutions a minute), is totally inadequate for a little motor running at 2,000 revolutions per minute. In the common type of indicator the pressure of the steam, or of the exploding gas, is allowed to act on a small piston, which is raised against a stiff spring and causes a pencil to move upward over the surface of a sheet of paper through a height proportional to the pressure. Simultaneously the sheet of paper is moved backward and forward by suitable mechanism, so as to keep time with the motion of the piston in the cylinder of the engine.

This type of indicator is unsuitable for high-speed work for several reasons. If the indicator piston is adjusted, as it should be, to move with very little friction, the suddenness of the explosion sets it in a violent state of vibration, which is well shown in the accompanying diagrams (Fig. 2), taken by Clerk from an engine running at 600 revolutions per minute. The vibration is due to the inertia of the piston and pencil mechanism; and since effects of inertia generally vary as the square of the speed, it is easy to see that such an indicator would be quite useless for a speed of 2,000 revolutions. It would also be very difficult, at this speed, to devise a mechanism capable of moving the paper accurately in time with the piston. These difficulties are overcome by employing (1) an elastic steel plate or diaphragm, in place of a piston and spring, to receive the pressure, and (2) a weightless ray of light, instead of a pencil and lever, to magnify and record the movements of the diaphragm. This form of indicator was, I believe, first suggested by Prof. Perry, and is made in a practical form for light motors, under the name of the Hospitalier-Carpentier manograph. Referring to Fig. 3, which shows the essential parts of the instrument in a diagrammatic form, the pressure is transmitted from the engine through a tap *T* by a long, flexible copper tube about a meter in length to the steel disk *D*, at the end of a box like a camera. A ray of light entering through a tube at *O*, in the side of the box, is reflected by a prism *P* on to a light pivoted mirror *M*, which is tilted up and down through a small angle by the movements of the steel disk. The ray of light is focused by the mirror on a ground glass or photographic plate *A B* at the other end of the box, so that the pressure acting on the disk is indicated on a greatly magnified scale by the movements of the spot of light. Unfortunately, the scale of pressure is not one of equal parts, so that the diagrams cannot be measured by a planimeter. In order to make the spot of light describe the indicator diagram, and show the pressure at each point of the stroke, the mirror is simultaneously tilted from side to side by the lever *L*, actuated by a little crank *C*, which is driven by a long flexible connector from the main shaft of the engine. When the engine is running at a high speed, the spot of light is seen as a continuous curve on the ground glass, which can be projected on a screen, and made

Fig. 4.—INDICATOR DIAGRAMS—COMPRESSION AND SUCTION.

visible to a large audience by using a sufficiently powerful source of light. In this manner the action of a high-speed engine can be more effectively studied and exhibited than that of a slow-speed engine with the ordinary pencil indicator. It is very fascinating to watch the changes of the diagram with every change in the ignition, or the load, or the speed of the engine.

SOURCES OF ERROR IN THE MANOGRAPH.

In applying this apparatus to an engine running at so high a speed as 2,000 revolutions, it was found necessary to make some modifications to secure accurate results. The long flexible tube for transmitting the pressure, and the long flexible connector for transmitting the motion of the shaft, were evidently intended to facilitate the connection of the apparatus to any kind of engine in any position; but they obviously introduce several sources of error, especially at high speeds. The propagation of the explosion pressure through the fine copper tube takes a very appreciable time, so that the maximum pressure on the disk is much later than the maximum pressure in the cylinder. This retardation may amount to half a stroke or more at high speeds, and would very seriously distort the diagram. To get over this difficulty the makers provide an ingenious arrangement so that the position of the spot of light may be retarded relative to that of the piston by an amount equal to the retardation of the pressure at any given speed. Unfortunately, the retardation required varies with every variation in the speed of the engine, and the adjustment interferes with the accurate reproduction of the motion of the piston, for which it is necessary that the small crank *C* actuating the mirror should be at the top of its stroke at the same time as the crank of the engine. Again, the pressure transmitted through the long, fine tube is not the same as that in the cylinder. In some cases I have found it as much as 25 per cent less. The long, flexible connector from the main shaft may also introduce

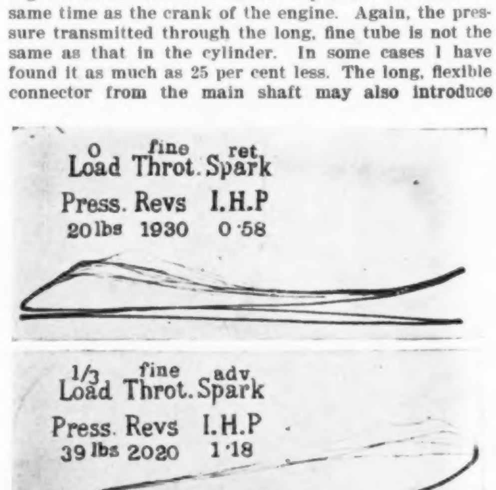


Fig. 5.—LIGHT LOAD DIAGRAMS.

variable and uncertain errors owing to its flexibility, and to torsional vibrations. These different effects combined may produce all sorts of curious errors and imperfections in the diagram, even at moderate speeds, such as 900 revolutions; and at high speeds the indications become quite untrustworthy.

In order to minimize these sources of error, the long copper tube was replaced by a short steel tube of less than one-tenth its length, and of more than three times its sectional area. The retardation was thus rendered

inappreciable, and the pressures indicated were the true pressures existing in the cylinder. The flexible connector was replaced by a pair of short steel rods engaging through a bevel gear, so that the motion of the piston was accurately reproduced. With these slight modifications the instrument was found to work quite satisfactorily at speeds of 2,500 revolutions per minute or more.

SAMPLE DIAGRAMS.

The first pair of diagrams, illustrated in Fig. 4, were taken with a thin steel disk (giving an open scale of pressures) to measure the compression and suction pressures with different adjustments of the tension of the spring of the automatic inlet valve. For these tests the engine was driven by an electric motor. In the top diagram, with the inlet spring at its maximum tension, and the opening of the valve limited to about one millimeter, the suction pressure is seen to be about half an atmosphere (7 to 8 pounds per square inch) at the end of the suction stroke. The pressure does not rise to the atmospheric line (the dark, thick line across the lower part of the diagram) until the piston is half-way back along the compression stroke. The compression pressure is only 33 pounds per square inch above atmospheric. The expansion line is practically coincident with the compression line, the current being switched off so that there is no explosion. Near the end of the expansion stroke the exhaust valve opens, and the pressure returns to the atmospheric line. During the exhaust stroke the pressure rises slightly above the atmospheric. If the compression pressure is reduced, by throttling, much below the limit indicated by this diagram, the engine will not fire regularly every time, as nearly half the cylinder contents consist of burnt gases from the previous stroke. The second diagram in the same figure shows the compression and suction with a weak inlet spring. The negative pressure of suction is only 3 to 4 pounds, a nearly full charge is drawn in, and the compression pressure is more than doubled, reaching 68 pounds. Under these conditions the mixture is much stronger, being less diluted with burnt gases, and the explosion pressure is increased in a greater ratio than the compression. The temperature of the explosion is also much higher, and the cylinder would overheat rapidly if not artificially cooled. The makers generally fit a much stronger inlet spring for various reasons; partly perhaps to prevent tyros overheating their engines at full throttle, partly to diminish the risk of the cotter falling out or hammering through the slot in the stem, partly to make the inlet valve close as quickly as possible at high speeds and prevent loss of charge, and partly to secure a sudden and violent suction at the carbureter jet, which gives a finer spray and a more intimate mixture.

The next two diagrams (Fig. 5) show the engine running at a high speed, with no load and with one-third load on the brake. The area of the no-load diagram is a measure of the work required to drive the engine and gear against friction, suction, and back pressure. In this diagram the engine was running fast, but with spark fully retarded. The lower diagram shows the engine running at one-third load on the same throttle with spark advanced. The exact point of the stroke at which the spark occurs cannot be determined from the setting of the spark lever by turning the engine slowly, because there is always some retardation of the spark at high speeds, due to loss of time in the mechanism. In order to determine the exact point, a spark gap was arranged at *S*, close to the light aperture *O* in Fig. 3; and a spark, produced by the same discharge as the spark in the cylinder, was made to photograph itself on the plate. This device of photographing the spark on the indicator diagram itself makes it possible to study the phenomena of ignition accurately under the actual conditions which occur in practice. The ignition of the charge is so slow with a weak mixture when rapidly expanding, as in the no-load diagram, that the maximum pressure is not reached till nearly the end of the stroke, although the spark itself takes place shortly after the beginning of the stroke. By advancing the spark so that it occurs before the end of the compression stroke, the explosion has time to develop while the piston is passing the dead center, and the ignition proceeds more rapidly in the hot compressed gas, so that the latent period is considerably shortened.

The next figure (6) shows the engine running under higher loads, with 30 and 45 pounds respectively on a brake applied to the back wheel. The first of the two diagrams shows the effect of too much spark advance. Ignition has already commenced before the end of the compression stroke. The explosion pressures are high and irregular, and the steel disk of the indicator is thrown into a violent state of oscillation, which is very pretty to watch on the ground glass, but does not reproduce very well in the photograph. In this case so much heat is lost to the walls of the cylinder before expansion begins, that the expansion pressures are reduced and the area of the diagram diminished. The second diagram, which was taken immediately afterward, with the same setting of the throttle, etc., but with less spark advance and a heavier load, shows much higher expansion pressures and a larger area. It is evident that more work can be obtained in a small cylinder by adjusting the spark advance so that the maximum pressure is reached shortly after the beginning of the expansion stroke. The elongated dots above the compression line are the photographic impressions of the sparks in both cases. Although the mean pressure is greater in the second case, the maximum pressure and temperature are less, so that less strain is put on the engine, and less heat is wasted in heating the walls of the cylinder. The indicated horsepower happens to be nearly the same in the two cases, because the large increase of load in the second case caused a reduction in the speed, as the tension of the inlet spring was too great to admit a full supply of gas, although the throttle was full open.

TEMPERATURE MEASUREMENTS.

The most important condition affecting the efficiency of the air-cooled motor is the temperature of the cylinder, the investigation of which, under conditions of running, was one of the main objects of these experiments. It is well known that if a motor of this kind is run on the stand at full throttle for a few minutes, either with

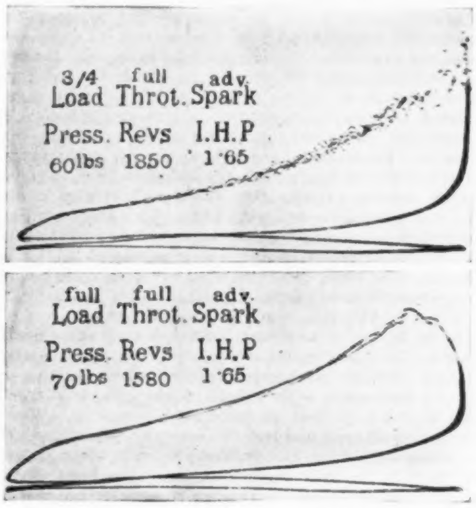


FIG. 6.—HEAVY LOAD DIAGRAMS.

the spark fully retarded or with a load on the brake, the exhaust valve and tube and the adjacent parts of the cylinder head quickly become red-hot. This does not necessarily stop the engine until some part of the barrel of the cylinder becomes so hot that the lubricating oil is vaporized, which causes leakage of gas and greatly increased friction. The rate at which heat is communicated to any part of the cylinder evidently depends (1) on conduction of heat from neighboring portions; (2) on the temperature of the gases to which it is exposed; (3) on the duration of the exposure; and (4) on the rate of motion of the gases over the surface. The last cause is usually the most effective, as the conducting power of a gas is low, so that comparatively little heat would be communicated by a quiescent layer of gas. The temperature actually reached by any part of the cylinder will depend obviously on the rate at which the heat is carried off by external cooling or conduction. Each part will reach a stationary temperature when the heat communicated to it by conduction and by the hot gases is equal to the heat carried off in the same time by conduction and by external cooling. To secure the most efficient action it is evident that the cooling should be arranged to keep the working surfaces of the cylinder as nearly as possible at a uniform temperature throughout. If any part becomes too hot, there will be failure of power and unequal wear. The observation of such differences of temperature as occur in the working of the engine, is the surest guide to appropriate methods of cooling.

THERMO-ELECTRIC METHODS.

It would not be at all an easy matter to measure the temperature at any point of the cylinder by means of an ordinary mercury thermometer, even if an instrument reading to 500 deg. C. could be employed. The bulb might be fitted in a copper block wedged between the cylinder ribs, and protected on the outside with asbestos; but it would be slow in following the temperature of the metal, it would be difficult to read, and liable to large and uncertain errors from stem exposure and conduction. The simplest and best method is to use a "thermo-couple" (or junction of two different metals) which produces an electric current depending on the temperature of the metals at their junction or point of contact, and practically independent of the temperature of other parts of the wires. The thermo-couples employed in this investigation were pairs of wires of iron and nickel, about one millimeter in diameter. The pair of wires forming each couple were firmly screwed, side by side, into small holes in the cylinder, so as to get good electric and thermal contact. Eight couples were employed in different positions, the other ends being connected to mercury cups, so that any desired couple could be quickly connected to a galvanometer or millivoltmeter for measuring the thermo-electric force. A sensitive galvanometer with a resistance of 400 ohms was generally employed in the laboratory in connection with the indicator diagrams, to avoid small errors from variation of resistance of the wires. The millivoltmeter, being portable and giving fairly steady readings when the bicycle was in motion, was employed for obtaining temperatures under the actual conditions of running the machine on the road. Since the readings of a thermo-couple are not, as a rule, by any means proportional to the true temperature, a preliminary series of experiments was made with one of the couples to compare its readings with those of a standard platinum thermometer. It was found that the thermo-electric power of the couple fell to less than half its initial value between 300 deg. and 400 deg. C., but increased again at higher temperatures. It was intended at one time to use a standard platinum thermo-couple with the wires gold-soldered into a single small screw; but these couples give a much smaller thermo-electric power at low temperatures, and were not so suitable for use with the millivoltmeter, besides being more difficult to fix.

INLET AND EXHAUST TEMPERATURES.

The temperatures of the cylinder head above the inlet and exhaust valves were measured by a pair of couples screwed into the metal just over the valves. Running the machine on the stand in the ordinary way at a speed of 2,000 revolutions, with spark retarded and throttle half closed, the temperature on the exhaust side rose to 570 deg. C. (a full red heat) in two or three minutes, while the inlet side remained comparatively cool. It would evidently be impossible to make any satisfactory tests under these conditions, as the exhaust valve would get burnt and the spring lose its temper. This was avoided by fitting a centrifugal fan on the fly-wheel inclosed in a case (shown in section in Fig. 1), with a duct delivering a blast on the exhaust side of the cylinder head, which not only made it possible to run the machine continuously on the stand without overheating the exhaust valve, but also doubled the efficiency of the machine when running on the road, especially at low gears. Using this fan, the temperature of the exhaust guide very rarely rose above 400 deg. C., even at full throttle, with the spark retarded and the engine running continuously. Variation of speed did not produce much effect on the temperature, because the velocity of the cooling blast was increased in nearly the same proportion as that of the exhaust gases. The highest temperatures of the head were obtained at full throttle with the spark retarded, as in Fig. 5 (lower diagram), because the greater part of the heating effect on the exhaust valve depends on the outrush of the hot gases at the moment of exhaust, and not on the explosion temperature. With the spark advanced, and running under load, the temperatures observed were 20 deg. to 30 deg. lower for the same setting of the throttle, as the exhaust gases were much cooler.

In order to more nearly imitate, in the laboratory, the conditions of running on the road, a second fan was arranged in some of the tests, to deliver a horizontal blast from the front on the head and barrel of the cylinder, at a velocity of about 25 miles per hour when the engine was running at a speed of 2,000 revolutions. The cooling effect of this fan was somewhat greater than that of the natural draft due to the speed of the machine when running on the road on the high gear. It acted chiefly, like the natural draft, on the head and front and on the inlet side of the cylinder, the exhaust side being somewhat screened by the frame and the petrol tank. With both fans running the exhaust seldom rose above 300 deg. C., or the inlet valve above 70 deg. C. At full throttle the cooling effect of the partly vaporized petrol was so great that the inlet was kept as cool as 30 deg. to 40 deg. C., in spite of conduction of heat from the adjacent parts of the cylinder head. The suction of cool mixture is so effective in cooling the inlet side of the head, that no auxiliary cooling device

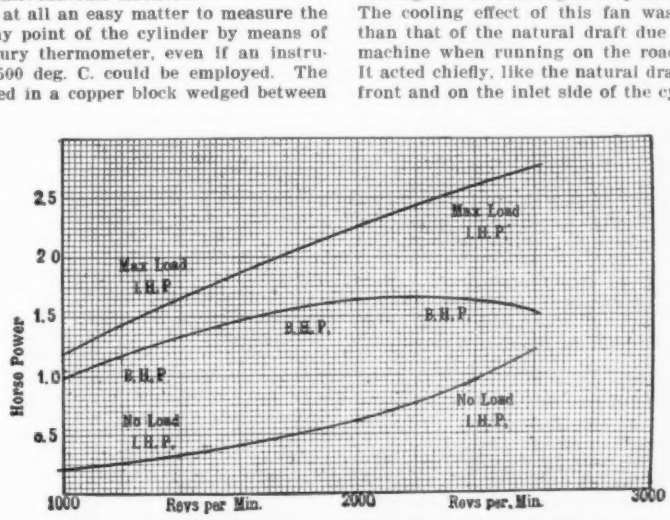


FIG. 7.—GRAPHIC REPRESENTATION OF RELATION BETWEEN HORSE-POWER AND SPEED.

at low gears is required on this side, beyond the natural draft.

TEMPERATURES OF THE COMBUSTION CHAMBER OR CLEARANCE.

The temperatures of the head or cover itself were measured on both the sheltered and exposed sides, and also the temperature of the barrel or curved surface above the end of the piston stroke. Without either of the fans, the exhaust side of the head and combustion chamber was 60 deg. to 100 deg. hotter than the inlet side after four minutes running light, when the engine began to show signs of overheating, and was stopped to avoid injuring the exhaust valve. With the fly-wheel fan to cool the exhaust side, the engine could be run continuously on the stand for any length of time at half or three-quarters load, and did not show signs of overheating till it had run for fifteen minutes at full load. Overheating took place on the inlet side, which was then 40 deg. to 50 deg. hotter than the exhaust side. With the fly-wheel fan it is impossible, even when running at full throttle on a low gear, to overheat the engine on the road, because the inlet side is fully exposed to the natural draft. Without the fly-wheel fan it was impossible to drive the forecarriage at full throttle, even on the highest gear. Overheating rapidly took place on the exhaust side toward the back of the cylinder. Using the machine as a bicycle, with less than half the weight to drive, it was possible to employ a higher gear, and the natural draft was not obstructed by the fore-car. It was very seldom necessary to drive at full throttle, except for a short time, and there was never any trouble from overheating, even without the fan. It was found, however, that the fan, which weighed less than two pounds in all, produced quite a perceptible increase of efficiency, even with the bicycle, because the cylinder was kept cooler and at a more uniform temperature.

With both fans running on the stand, the temperature of the combustion chamber at full load never rose above 200 deg. C. (392 deg. F.) on the exposed side, or 260 deg. (468 deg. F.) on the sheltered side, away from the larger fan. The temperature of the greater part of the barrel on the front side was below 150 deg. C. (302 deg. F.), but rose as high as 200 deg. C. on the sheltered side at the back. This was well below the temperature of overheating, which does not begin until a temperature of 300 deg. C. (572 deg. F.) is reached at the upper part of the piston stroke. The temperature of overheating depends, to some extent, on the quality of the oil used for lubrication; but most oils for air-cooled cylinders contain a residue which is sufficiently thick and non-volatile for the purpose at this temperature. Of the thinner qualities a larger quantity would be required, but the residue would probably be similar.

EFFECT OF CONDUCTION.

It is well known that air-cooled cylinders of large diameter are more liable to overheat than small cylinders. The reason of this is not obvious at first sight, because the external cooling surface is increased in the same proportion as the internal surface receiving heat. The explanation is twofold. In the first place, the volume of hot gas in the cylinder increases in proportion to the square of the diameter; so that its average temperature in the larger cylinder remains higher throughout the stroke, and a greater quantity of heat per unit surface is communicated to the walls, as the gas is very far from being in a quiescent state. In the second place, the rear side of the cylinder is necessarily screened from the natural draft created by the motion of the machine. Cooling at the back depends chiefly on conduction of heat round the cylinder to the cooler sides. Even in the small C. G. cylinder, only 60 millimeters in diameter, the back may be as much as 50 deg. or 100 deg. C. hotter than the front. In a larger cylinder, say 80 millimeters in diameter, the difference of temperature required to carry away the heat by conduction may be more than twice as great. The back is more effectively screened on account of the size of the cylinder; the quantity of heat to be carried away by conduction is much greater, as explained above, than in the proportion of 80 to 60, and it has a greater distance to travel, as the diameter is increased. In any case, whether the engine is large or small, the rear of the cylinder will overheat sooner than the front. The remedy is evidently to arrange a cooling fan, somewhat as indicated in Fig. 1, to deliver a blast across the back of the cylinder, so as to keep the whole at a more nearly uniform temperature, and enable the motor to run at higher power or for a longer time without overheating.

EFFECT OF PISTON CONVECTION.

Three of the thermo-couples were arranged in a line down the side of the cylinder, at the top, middle, and bottom of the piston stroke, in order to observe the distribution of temperature along the length of the cylinder. It would naturally be expected that, since the barrel surface at the top of the stroke is exposed to the full heat of the explosion when the gases are hottest and densest, and is also exposed to the high temperature for a much longer time than the lower part of the cylinder, there would be a very great difference of temperature between the top and bottom of the stroke. This would necessarily be the case if heat were transferred along the barrel by conduction only. At first sight one of the most curious results of the measurements was, that there was very little difference of temperature along that part of the barrel surface which was swept by the piston. When the top was at 200 deg. C., the bottom of the stroke was at 180 deg. C., a difference of only 20 deg. in 70 millimeters. The reason of this, as explained in a previous paper on the steam engine (Proc. Inst. C. E. 1898) is that, in a high-speed engine, convection of heat by the piston plays a much more important part than conduction, in the longitudinal distribution of temperature. The piston at the top of its stroke absorbs heat from the upper part of the barrel, and carries it very quickly to the lower end, where it is absorbed by the cooler walls. The greater the speed, the less the difference of temperature which can exist between the two ends. This action of the piston is most important in cooling the upper part of the barrel and distributing the heat over a wider surface. It is also an advantage in equalizing the fit of the piston at the two ends of the stroke, which would be materially affected by expansion of the cylinder if the temperatures were very different.

It might naturally be expected that the lower parts of the cylinder would be relatively hotter when the spark was retarded, so that a greater part of the surface was exposed at the time of maximum temperature. The reverse, however, is the case. More heat is communicated to the barrel surface when the spark is advanced, owing to prolonged exposure; and this heat is distributed uniformly along the barrel by piston convection. Retarding the spark raises the temperature of the head, owing to the outrush of the hot exhaust, which does not much affect the barrel surface unless the valve chamber is at the side. The high temperature of the lower part of the barrel, due to piston convection, is an objection to the now prevalent fashion of omitting the lower ribs. This, however, is done chiefly for convenience of casting.

THE EFFICIENCY OF FAN COOLING.

It is generally admitted, except in advertisements, that no air-cooled engine can work at full power continuously without overheating, except when running at a very high speed with a light weight on a level track, and with a high gear suitable only for racing. Where such a machine is required to carry two passengers and to climb hills on a low or medium gear, some makers fit a little fan to stir the air round the head of the engine, but the majority are reverting to water cooling as the only satisfactory method. It seems to be generally considered that the power wasted in driving the fan is greater than the power gained by more effective cooling. This misconception arises chiefly from inefficient methods of constructing the fan and applying the cooling blast. Some instructive experiments were made on the power required to drive the fans, in addition to the experiments already mentioned on the cooling effect produced. The fly-wheel fan absorbed so little power that it was very difficult to detect or measure the power absorbed. By employing a small electric motor to run the fly-wheel alone in its bearings (the piston and the rest of the engine gear being removed) with and without the fan attached, it appeared that the power absorbed at 2,000 revolutions did not exceed 1-30 of a horse-power, which is quite negligible in comparison with other losses. This very small outlay of power, properly applied, makes all the difference, when carrying a load of five hundredweight up a long hill like Hindhead, between the motor overheating hopelessly and coming to a stop in the first half mile, and racing up the whole three and a half miles at full throttle. The larger fan, which was used for the horizontal blast on the front of the engine when running on the stand, had separate bearings and was more easily tested. When mounted without a case in the manner usually adopted, so as to disturb the air in all directions round it, it absorbed 1-10 of a horse-power at 1,500 revolutions, and gave a blast of 12 to 15 miles per hour at the engine. When inclosed in a suitable case, arranged to concentrate the whole blast on the engine, it took only 1-20 of a horse-power at the same speed, and gave a blast of 25 to 28 miles per hour. That is to say, it worked at no less than four times the efficiency. It kept the engine rather cooler than when running full speed on the road, but it was better to be on the safe side in testing the engine on the stand. The velocity of the blast was found to vary directly as the speed of the fan; and the power required to drive it, nearly as the cube of the speed.

INDICATED AND BRAKE HORSE-POWER.

The nominal horse-power of a motor is generally estimated from the cylinder dimensions and the speed. In some cases it is determined experimentally by a brake applied to the fly-wheel. The conditions of this test are somewhat artificial, and it is not surprising to find that the motor generally fails to develop its nominal power on the road. The power available at the road wheel is, of course, necessarily less than that given at the motor pulley, on account of losses in transmission; but even making allowance for losses in transmission, a large percentage of the petrol cars in the last reliability trials failed to realize as much as half their nominal horse-power on the test hills. The average for the small cars, taking only those which successfully completed the runs, was only 2-3 of their nominal power. With the aid of accurate indicator diagrams, it is possible to measure the gross or indicated power directly, and to investigate sources of loss of power in a more satisfactory manner. The indicated horse-power stated on the diagrams already given was obtained by subtracting the mean backward pressure of the compression stroke from the mean forward pressure of the explosion stroke, multiplying by the volume of the cylinder, and by the number of explosions per minute (half the number of revolutions, as there were no misfires) and by the appropriate factor to reduce to horse-power. The suction and back-pressure during the pumping strokes might have been deducted to obtain the net indicated horse-power, but it is more convenient to include these with the mechanical losses. The maximum brake horse-power available at the engine pulley is most easily deduced from the indicator diagram by subtracting the indicated power when the engine is running light at the same speed with spark retarded, but otherwise under similar conditions. This neglects the effect of increased engine friction (included with transmission losses), but it has the advantage of eliminating certain small possible errors of the high-speed indicator. The accuracy of the gross indicated power was tested by belting the engine to an electric motor, and driving the combination by switching on the engine and the electric motor alternately. The power required was 1.52 horse-power from the indicator measurements, and 1.48 horse-power from the electrical instruments, the speed being the same in both cases. The small difference is readily accounted for by a very slight slipping of the belt on the engine pulley, when the engine was working.

The power required to run the engine light with the cylinder hot was also measured in the same way by an electric motor at various speeds, and the results were found to be in very satisfactory agreement with those deduced from the indicator diagrams at no load. The general results with regard to the maximum brake horse-power available at the engine pulley are shown in the curves in Fig. 7. The upper curve shows the gross indicated power at various speeds with full throttle and the best mixture. The lower curve shows the power running light under the same conditions. The middle curve shows the difference, or the maximum brake horse-power. There seems to be a very general impression that the brake horse-power increases in direct proportion to the speed.* As a matter of fact, it appears that even the gross indicated power does not increase in direct proportion to the speed. The curve is concave to the axis of speed, and shows a lower rate of increase at high speeds. The no-load curve, on the other hand, is convex to the axis of speed, and rises more steeply as the speed increases. The first effect is chiefly due to unavoidable diminution in the charge of gas at higher speeds; the second, to increased losses from suction, back-pressure, and friction, which are equally unavoidable. As a result there is a particular speed at which the brake horse-power is a maximum, which in the case of this particular motor is near 2,200 revolutions at full throttle under the ordinary conditions of use. No doubt it would be possible, by fitting lighter valves, and a larger carbureter, and by omitting the silencer, to get a bigger brake horse-power at a higher speed. But an artificial test of this kind would be of little or no value except for purposes of advertisement. It will be observed, moreover, that the indicated horse-power actually realized under the ordinary conditions of use, namely, 2.26 at 2,000 revolutions, corresponding to a mean effective pressure of nearly 80 pounds, is very good for so small an engine, without scavenging and with a very hot cylinder. With a much larger water-cooled motor, and 50 per cent higher compression, the best mean pressure hitherto realized is only about 90 pounds. In a small high-speed engine the losses due to the action of the walls are necessarily greater, and one can hardly expect to realize the same effective pressure.

EFFICIENCY OF TRANSMISSION.

A most important question for the user of a motor cycle is the power actually realized at the road wheel, which depends on the efficiency of transmission, as well as on the efficiency of the motor. Very little is known about this point, as it is rather difficult to test under the conditions of use. In order to get some idea of the power required at the road wheel, an epicycle gear of special construction was fitted to the cycle (in addition to the ordinary Garrard two-speed gear) giving a practically continuous range of gears from 8 to 16 revolutions of the engine to one of the road wheel. This was arranged in such a manner that it could also be used as a transmission dynamometer to measure the actual pull on the driving wheel when the machine was running on the road. The test was made in both directions along the same stretch of road, to eliminate the effect of slight gradients and of wind resistance. A simple speed indicator was employed to deduce the power. With the fore-carriage attachment and a total load of five hundredweight, it was found that a pull of 18 to 20 pounds was required to drive the machine on a good level road at a speed of 20 miles per hour. This is equivalent to one horse-power. At this speed the engine was running well within its power, but it was clear that a good deal was lost in the transmission. The result of the road test was verified by measuring the power developed by the engine on the stand with a special brake applied to the back-wheel tire. It was found that the engine actually gave a little over one horse-power on the back wheel under the conditions used in the road test. At full throttle it would do rather better, the maximum realized being 1.15 horse-power on the wheel, against 1.64 brake horse-power at the engine, giving an efficiency of 70 per cent. This is a very fair efficiency of transmission, considering that the power was transmitted through four chains and two epicyclic gears, and that the transmission loss includes increased engine friction. The chains were rather worn and rusty, and the gears had run 3,000 and 4,000 miles respectively. Better results might have been obtained with new chains and all the gear in first class condition, but the above may be taken as fairly representing the conditions of ordinary use. A single belt would give as much loss as the four chains, and would not work at a gear of 16 to 1, besides giving far more trouble in dirty weather.

There are many other questions of interest to the motor cyclist at the present time, which might profit-

* This misconception has probably arisen from the very general use of carburetors which require flooding to start, and will not give a good mixture at low speeds.

ably be discussed in the light of the information afforded by the indicator diagrams and the temperature measurements. Such are: The relation of fuel consumption and richness of mixture to cylinder temperature and useful effect obtained. Loss of power due to suction and back-pressure. Overheating and loss of power due to leakage of valves, or piston rings, or head joints. The advantages of automatic, as compared with mechanically operated inlet valves, or *vice versa*. The velocity of the explosion and the power obtained as related to the character of the spark, the amount of advance, or the addition of other substances to the petrol. The influence of compression on the economy. The advantages of multiple as compared with single cylinders. The efficiency of different kinds of lubricants, and a host of other questions. Some of these are now under investigation, and may be discussed on a future occasion. The most important point for the motor cyclist is to secure the maximum of power and flexibility with the minimum of weight and other inconveniences. With this object, the first essentials are a variable speed gear of wide range, and some efficient method of cooling to prevent overheating at low gears. It is no use to fit a mechanical inlet valve in order to get more power, when the automatic valve already overheats the motor. It is unscientific to double the weight and power of the machine in order to climb a few hills, when the same result, with far greater flexibility of control, can be secured by a variable gear. It is unnecessary to resort to the weight and complication of water cooling when a light fan will do all that is required. How this method has been applied in a particular case is shown in the present article, and the principles underlying the application have been explained so fully that there should be no difficulty in applying the method with satisfactory results in other cases.

THE FALLACY OF THE TESTS ORDINARILY APPLIED TO PORTLAND CEMENT.*

THE qualities which are requisite for a good Portland cement are those which insure that concrete made from it shall be of sufficient strength to withstand any and all strains, stresses and shocks to which it may be submitted, not only when first made and allowed to harden, but after the lapse of many years. The tests now applied to cement all aim to search out these qualities, or show their absence, and may be classed under two general heads, i. e., those designed to show the strength of concrete made from the cement, and those designed to show its endurance. Under the first head come the tests for tensile strength, compressive strength, fineness to which the cement is ground, as this influences its sand-carrying capacity and hence its strength, and time or rate of setting, as quick-setting cement may not give sufficient time for proper manipulation of the concrete and slow-setting cement may take too long to get its strength. Under tests for endurance come the various so-called soundness tests, and possibly chemical analysis, as the quantities of magnesia and of sulphur trioxide present are supposed to have an influence upon endurance.

It is the writer's intention in this paper to discuss some of the false conclusions that may be drawn from a too rigid interpetation of the results of these tests even when they are properly manipulated. Improper manipulation or the varying results due to the personal equation of the operator or the different percentages of water used in gaging the mortar, or the sundry modes of making briquettes and pats, troweling, ramming, shaping, etc., enter no part into it, and for the sake of simplicity it is supposed that the results of different operators agree. It is well to say, also, at the outset that it is not the writer's intention to advocate any new system of cement testing nor to suggest that the present one be done away, but merely to point out certain weaknesses which limit its general application to every case, and to recommend a stronger leaning toward those tests which show the strength and endurance of sand mortar rather than neat cement.

Soundness.—The tests ordinarily applied to Portland cement are those for soundness, tensile strength, fineness and rate of set. These are placed in the order of relative importance as considered by most inquirers. Unquestionably the most important test of cement is that of its endurance, or the test for soundness, and this test has certainly the right to be the one most widely discussed. It is unfortunate that the test which seems to be accepted by the majority as a standard is the long-time cold-water pat, a test requiring such length of time for its completion as to practically forbid its use. The conditions of the case demand a rapid test in order that the consumer may not be required to store the cement for a long period of time while he awaits the results of his cold-water pats. Quite a number of these rapid tests have been proposed, chief of which are the boiling test devised by Prof. Tetmajer of Zurich, and the steam test recommended in its preliminary report by the last committee of the American Society of Civil Engineers on cement testing. A milder test much used in England is the warm water test of Faija in which the pats are allowed to harden over water kept at 120 deg. Fahr. for six hours and then immersed in the latter for eighteen hours. Very little cement which fails on the boiling test will pass a five-hour steam test, but a great deal of that failing on the boiling and steam tests will pass the Faija test satisfactorily.

To the manufacturer the boiling test is an exceedingly useful one, for if a cement will pass this test it will pass any test to which it may be subjected. He can not hold his cement in his stock house for months while he ascertains if it will pass the cold-water pat test, and so he applies an accelerated test to tell him if this cement will pass the tests to which it is likely to be put. To my mind there is a strong comparison between the boiling test and the color test for carbon, so much used in the steel works laboratories. While this latter test is very useful to the manufacturer, still no engineer would condemn steel on the result of such a test, for though it may give correct results in nine out of ten cases, he does not care to take the risk of this being the tenth case and of throwing out a good steel, and so working great hardship to the manufacturer.

Unquestionably much good concrete has been made from so-called unsound cement, and this is the key to the whole objection to the boiling test. It is probable that much of the first American Portland cement would not have passed the boiling test, yet it is upon the merits of the work done with this cement that engineers are now using American instead of imported cement. Butler gives a strong plea for the Faija test and states that in the twenty years this test has been in use, no cases of failure in work by cement passing this test have come under his observation. If the Faija test is severe enough to exclude all bad cements, then the boiling test is needlessly severe, as it rejects many cements which pass Faija's test.

All cement probably contains some free lime. From the nature of the case this must be so, since cement raw materials are not ground to a degree of fineness nor carried to a state of fusion which would permit of every molecule of lime coming in contact with a molecule of silica or of alumina. Now there are limits beyond which if the uncombined or free lime goes, certain results will take place. Let us suppose that with a very small percentage present the cement will fail on the boiling test but pass satisfactorily five hours in steam, and if a still larger percentage is present it will fail in the steam but pass the Faija test. Now, again, let us suppose that a neat mixture with a certain small percentage of free lime is sound, with a larger percentage a 3:1 sand mixture is sound, with a still larger percentage a 1:3:8 concrete is sound. (It is well understood that the tendency to disintegrate is greater in a neat paste than in a sand mixture, and anyone with experience in cement testing knows of cases where neat briquettes were disintegrated in time and yet the sand ones were sound and strong.) Now how do we know that the limit of lime which may be present in good cement (that is cement which will make enduring concrete) is coincident with that maximum which may be present for a sound boiling test?

Nearly all advocates of the boiling test have tried to prove these two limits coincident by comparing the boiling test with the results of neat pats and neat briquettes. Usually the coincidence of a failure on the boiling test with either a warping or cracking of neat pats or a loss of strength in the neat briquettes on long time tests is considered competent evidence in favor of the boiling test. In reality cement is seldom used neat. A cement which fails on the boiling test, whose neat briquettes fall off in strength after 7 or 28 days, yet whose sand briquettes increase in strength as they grow older, has certainly given evidence that it will make good concrete. In weighing evidence for the boiling test it must be remembered that we do not make this test to see if neat briquettes will fail in strength as they age or if neat pats will warp and decay, but whether sidewalks, piers, abutments, foundations, walls, floors, and buildings of concrete, not neat cement, will be permanent, and the thing therefore to compare the boiling test with is concrete. Not until we can compare our laboratory records with many examples of both failures and successes in actual work shall we have reliable data for forming our conclusions as to the reliability of the various tests for soundness.

At the last meeting of the American Society for Testing Materials Mr. W. P. Taylor, of the Philadelphia Testing Laboratory, read a very carefully prepared paper upon the boiling test [printed in the Engineering Record of August 15, 1903] in which he compared the results of neat briquettes and neat pats with the results of the boiling test. As is usual, he considered a falling off of the strength of neat briquettes on long time tests and a cracking and warping of the neat cold water pat as being positive evidence of the presence of injurious constituents in the cement. He gives these figures: "Of all the samples failing to pass the boiling test, 34 per cent of them developed checking or curvature in the normal pats or a loss of strength in less than 28 days. Of those samples that failed in the boiling test but remained sound for 28 days, 3 per cent of the normal pats showed checking or abnormal curvature in 2 months, 7 per cent in 3 months, 10 per cent in 4 months, 26 per cent in 6 months, and 48 per cent in one year; and of these same samples 37 per cent showed a falling off in tensile strength in 2 months, 39 per cent in 3 months, 52 per cent in 4 months, 63 per cent in 6 months, and 71 per cent in one year. Or taking all these together, of all the samples that failed in the boiling test, 86 per cent of them gave evidence in less than a year's time of possessing some injurious quality.

"On the other hand, of those cements passing the boiling test, but one-half of 1 per cent gave signs of failure in the normal pat tests and but 13 per cent showed a falling off in strength in a year's time."

Mr. Taylor after making these comparisons acknowledges their fallacy by one of the closing paragraphs of his paper:

"Now finally we come to what is after all the most vital question of all, and this is the relation of the results of the boiling test to the conditions found in actual work, and there every tester of cement runs up against a stumbling block, for while almost every one connected with testing can cite instances of failures in the boiling being corroborated by failure in the work, it nevertheless cannot be denied that in the vast majority of cases work done with cement determined in the laboratory to be unsound will give most excellent results in practice and show not the remotest sign of any sort of failure."

Experiments made by a committee of the Society of German Portland Cement Manufacturers in connection with the Royal Testing Laboratory at Charlottenburg forced them to report in 1900 and again in 1903 that none of the so-called accelerated tests for constancy of volume was adapted to furnish a reliable and quick judgment in all cases concerning the applicability of a cement. The experiments which they made consisted in putting the cement into actual work and observing it during a period of four years. The committee recommended the 28-day cold water pat as a standard test. If this test is taken as a standard the boiling test will reject two good cements for every bad one according to Mr. Taylor's figures, as he states only 34 per cent of the failures on the boiling test were corroborated by failures in the 28-day normal pats.

Tensile Strength.—Perhaps the results of no test are given so prominent a place in the manufacturers' advertisements as the neat strength of briquettes made of his brand. We hear the question constantly propounded by the prospective purchaser of "How much does your cement pull?" and a thousand-pound neat 7-day break is considered compensation for all the deleterious qualities a cement may have. In reality, the neat break is not of so much value as we are apt to suppose, and taken by itself is little criterion of the quality of cement. Unsound cements often give notoriously high results and the addition of plaster or gypsum will also increase the neat strength. In both of these instances there is apt to be on long time breaks a falling off in strength, permanent in the former case and usually only temporary in the latter case.

A fact that is generally known is that up to a certain point coarse grinding of the cement will give higher neat results than fine grinding. A cement 75 per cent of which passed a 200-mesh sieve gave after 7 days a neat strength of 912 pounds and a sand strength of 256 pounds. The finer portion of this cement, that passing a 200-mesh sieve, gave for the same period a neat strength of 715 pounds and a sand strength of 463 pounds. A sample of float (i. e., the fine cement dust which collects on the beams, etc., in a cement mill and which is nearly all of it an impalpable powder) gave for 7 days a neat strength of 679 pounds and a sand strength of 558 pounds. This dust mixed with 25 per cent of coarse cement, i. e., that passing a 100-mesh screen but retained on a 200-mesh, gave 919 pounds neat but only 252 pounds sand strength in 7 days. Certainly in both these cases neat strength would have given us a poor comparison of the value of the two products. As cement is always used with sand, the sand strength is the important thing.

Another point which has often been brought against cement, and American cements in particular, is that of a permanent drop in tensile strength after the 28-day test. In fairly quick setting cements with their usual low lime content and to which the normal amount of gypsum or plaster has been added, this drop is rarely met with and is probably then due to improper manipulation of the test. In cements high in lime, without being necessarily unsound, or in cements to which a large addition of plaster or gypsum has been made, this drop is often met with. In unsound cements it is usually met with often after the 7-day test.

While it is true that any drop in strength indicates a disrupting action, still cement is never used neat and in the vast majority of cases when a cement shows a slight falling off in neat strength, the sand strength increases with age. Humphreys states that the compressive strength of neat cement does not experience this drop when the cement is sound even if the tensile strength does fall off somewhat after the 28-day test; an important fact, if true, as cement is seldom if ever used in tension. This brings us to the question if it is not a fallacy to subject a material to a tensile stress to see if it will stand a compressive one.

Coarse grinding of the cement has some influence on the increase in strength with age. A very fine cement increases neat very little after 7 days, while a coarser one keeps on increasing. This is no doubt due to the fact that the coarse particles are acted on much slower than the fine ones, and solution and crystallization of these go on after the finer ones are all hydrated. The following experiment was made with the same cement. Cement A is just as it comes from the mills. Cement B is cement A with the coarse particles (residue on a No. 200 sieve) removed:

Age.	7 days.	28 days.	3 mos.	6 mos.	9 mos.
Cement A. lbs.	618	695	675	725	750
Cement B. lbs.	518	546	535	510	549

Fineness.—The most rigid fineness specification could be filled by a cement which would be many degrees too coarse. Some of the older specifications could be easily filled by a product which would show almost no setting qualities and no sand-carrying capacity. If a sample of clinker is crushed in an iron mortar by a pestle and sieved as far as it is ground

* Read at the Lehigh Valley Section of the American Chemical Society, by Richard K. Meade.

through a 100-mesh screen a product will be obtained 100 per cent of which will pass a 100-mesh screen. Many of the older specifications call for only 90 per cent. If a pat is made of this cement it will just about cohere. If, however, the fine particles are sieved through a 200-mesh screen and the flour washed off the coarse particles by benzine and the latter driven off by heat, the product will still all pass a 100-mesh sieve and yet will have no setting properties. If another sample is ground in a mortar and sieved after every few strokes of the pestle through a 200-mesh screen it will nevertheless be almost worthless as a cement. When washed free from its flour with benzine it will just about hold together. In the writer's laboratory there is a Braun's gyratory miller for grinding samples, in which the grinding is done by an inclosed round pestle revolving in a semi-hemispherical mortar. In the bottom of the mortar is a hole which can be stopped by a plug. The grinding may be done in two ways, one by feeding the sample into the hopper in the cover and allowing it to work its way out at the bottom, then sieving out the fine material from the coarse, and returning the latter through the grinder, and so on until all has passed the sieve; the many mills using different systems of grinding the sieve test is hardly to be expected to give the relative percentage of flour in each. The product of the Griffin mill and of the ball and tube mill probably differ much in the percentage of flour present, even when testing the same degree of fineness on the 200-mesh sieve. Even with the ball and tube mill system one ball mill and two tube mills would probably give a product with a higher percentage of flour than one tube mill and two ball mills, even when the cement was ground to the same sieve test. The size screen on the ball mills probably also influences the percentage of flour in a product of a certain fineness.

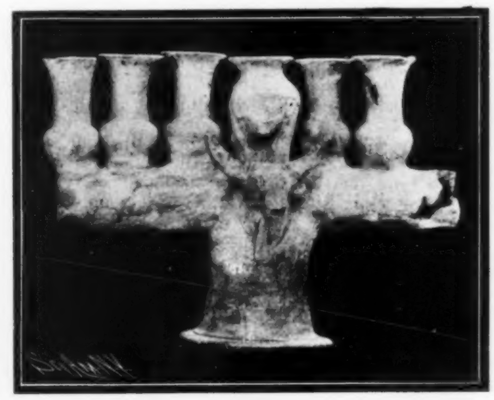
Rate of Set.—The test for setting time is of course influenced by many laboratory conditions, such as temperature and manipulation. This test, however, is seldom used as a basis of comparison, but merely to see if the cement is sufficiently slow in its setting action to be properly manipulated, or whether it hardens rapidly enough to satisfy the requirements of the work on which it is to be used. The fallacy in the case of this test lies in the terms initial and final set. These terms are meaningless, as "set" is a chemical reaction which begins with the addition of the water and goes

STRIKING OBJECTS FOUND AT CARTHAGE.

By the Paris Correspondent of the SCIENTIFIC AMERICAN.

THE ancient civilization of Carthage is now well illustrated by the countless number of objects which have been taken from the tombs by the excavations of Rev. P. Delattre. On the site of Carthage is a very extensive museum, in which the objects are placed as they are brought up, and it now forms the center for the study of the Punic period of Carthage, which is, of course, the most interesting, as well as the later Roman and Byzantine periods. Most of the objects are taken from tombs of different epochs, and the most ancient tombs often lie at a great depth, some of them at 30 feet below the ground. The soil of Carthage, so fertile in discoveries, is composed of layers resembling geological strata, lying one above the other. Near the top are Arab remains of later and older periods, then come Christian and Pagan epochs, the Roman period of Carthage, and last of all the Punic period. Some of the objects belonging to the latter period will be described as throwing light upon a number of interesting points.

MOUTH OF A CARTHAGINIAN TOMB WITH ROOF.



SEVEN-BRANCHED CARTHAGINIAN CANDLESTICK.

A WELL AT CARTHAGE.

other, by placing the plug in the bottom of the mortar and allowing the pestle to work upon the material until the latter has reached the desired fineness. Two samples of cement were prepared from the same lot of clinker by these methods. One sample, the one made by passing the clinker through the miller and sieving out the 200-mesh particles after each grind, would of course all pass a 200-mesh sieve. The other sample, the one made by grinding the whole sample to the desired fineness without screening, tested 96 per cent through a 100-mesh sieve and 76.5 per cent through a 200-mesh sieve. Sand briquettes were made of these two lots of cement with the following results:

Samples made by:	7 days.	28 days.	3 months.	6 months.
Grinding and screening to fineness (all 200 mesh) lbs	Broke in clips	Broke in clips	Broke in clips	28
Grinding to fineness without screening .	215	295	325	318

The cementing value of Portland cement depends upon the percentage of those infinitesimal particles which we call flour. No sieve is fine enough to tell the quantity of these present. At the same mill it is probable that the sieve test is relative, but to the engineer who is called upon to examine the product of on indefinitely, or merges into possibly another chemical reaction, if you wish to consider "set" and "hardening" as different phenomena. To fix two points in this reaction by means of loaded wires and call them the beginning and end of the reaction is a misnomer. It would be better to use the terms heavy and light Gillmore wire, or some similar term if other apparatus for determining the set is used.

A Method of Coloring Electric Light Bulbs and Globes.—We have had no practical experience in the direction of coloring glass globes or bulbs, but should not imagine that there is any difficulty about it. Two substances suggest themselves as excellent vehicles of color, and both water soluble—water-glass (potassium or sodium silicate) and gelatin. For tinting, try water-soluble anilin colors. The thickness of the solution will have to be a matter of experimentation. Prior to dipping the globes they should be made as free as possible from all grease, dirt, etc. The gelatin solution should not be so thick that any appreciable layer of it will form on the surface of the glass, and to prevent cracking, some non-drying material should be added to it, say glycerin.—National Druggist.

One of the most interesting finds was the tomb of Iadamelek. At a depth of 22 feet below the surface, the excavators came upon the roofstones of the tomb, which are extremely heavy, being 20 inches thick and 10 feet long. A breach was made in one of them, just enough to pass the body. This tomb is one of the largest which have been found at Carthage. The interior is a large chamber, built, as usual, of cut stone, and measures about 8 by 5 by 5 feet. The remains lie at a depth of nearly 30 feet from the ground. The tomb contained two skeletons, with a gold ring and a bronze bracelet in place around the bones of the arm. The walls and even the floor are overlaid with a coating of stucco. This material is very fine and hard, and has the whiteness and crytalline aspect of snow. The flame of the candles made it sparkle with a thousand luminous points. A part of the coating was detached and had fallen in large plates upon the skeletons. Another part had kept its original height, about four feet, but was inclined from the wall like a piece of bristol board. The density of the stucco was such that at the least shock it gave a metallic sound. A wood cornice originally ran around the upper part, and the chamber also had a wood ceiling. These had now fallen in a

brown powder, which covered the skeletons almost entirely.

All the funerary objects usually found in the Carthaginian tombs were in their accustomed places. Among these may be mentioned a group of vases, one a great vase which had the mouth stopped by an ostrich egg. In the corner was a large vase of cylindrical form. Near the head of the skeleton was a vase of red earth with black-painted geometrical patterns. It had been broken in pieces by the falling of the ceiling. A gold ring and a bronze bracelet were found here. On sifting the debris, a number of gold and silver jewels and other objects came to light. Among these is one of the most interesting discoveries which has yet been made at Carthage. It is a small gold disk only five-eighths of an inch in diameter, with a Punic inscription engraved upon the surface. According to M. Berger, who translated it, the inscription is one of the most remarkable. The writing is of the Archaic style and has scarcely any trace of the later transformation which the Phenician alphabet underwent at the Persian epoch. It seems to belong to the fifth or sixth century B. C. It is not only the first Archaic inscription coming from Africa, but in fact one of the oldest specimens of Phenician writing which exists. It reads: "To Astarte—Pygmalion, Iadamelek, son of Padai. Pygmalion delivers whom he pleases." The name of Pygmalion takes us back to the origins of Punic civilization and illustrates in an unexpected manner the accounts given by ancient writers as to the foundation of Carthage. It seems that Pygmalion, associated with Astarte, was adored as a deity during the 5th or 6th century. Now that we have the name of Pygmalion, perhaps that of Dido may also come to light.

At a depth of 10 feet below ground a very curious construction was found. It is a cylindrical well about 3 feet in diameter, whose lower portion for a height of 22 inches is formed of masonry and coated inside with a very solid dark gray mortar. The bottom is formed of conglomerate or rough mosaic. Above the masonry the well continues and is made up of four superposed rows of terra-cotta cylinders or jars with a hemispherical bottom (see engraving). The jars measure about 20 inches in depth and 8 inches diameter. They are disposed in a circle around the well, and each range contains twelve jars. The intervals between the mouths have been carefully stopped with a gray cement so that the whole makes a tight reservoir. The interior aspect of the well with the cylindrical jars may be compared with that of a tubular boiler, and is quite striking. It seems that this method of construction was used to increase the volume of the recipient and perhaps also to multiply the surfaces. But its use is not quite clear, and none of the savants who saw it could explain it satisfactorily. One opinion was that it might have been used for drying small objects at a moderate temperature, such as clay statuettes and vases, before going to the baking furnace. In fact, in the neighborhood are three furnaces of the Punic period, which bear traces of high heat, and the great quantity of broken vases which were found around them makes it likely that they were used for baking the large water jars.

A most striking object which was found in one of the large tombs is a kind of vase of complicated form which one of the engraving shows. It is of gray earth of common quality. Seven tubular pieces having a vase form, about 3 inches high, are fixed in a row upon a hollow cylinder with which they communicate. The main cylinder is 12 inches long and rests upon a slightly conical foot 4 inches high. In the middle of the cylinder is a cow's head projecting toward the front, with long and well-shaped horns. The head is pierced with a hole which communicates with the cylinder. Above it is the mask of the Egyptian goddess Hathor. This head ornaments the face of the central cup.

The first impression we have on seeing this singular object is that of a seven-branched candlestick, and it might be supposed that the cups were used to hold a wick made of willow pith, which is fed by the oil in the main cylinder. A cork was no doubt placed in the cow's mouth. M. Maspero, the eminent archæologist, gives another use for this object. He says that it recalls the plates provided with cups or cylinders which are often found in Egyptian tombs. The cups are six or eight in number, ranged in two rows, or nine in three rows. Often seven are found in a single line.

A WINGED CARTHAGINIAN SPHINX.

These are placed on a flat support, but do not communicate. The form of the cup is somewhat like the present. Such objects were used as offerings, and the cups contained liquids, etc., which were presented to the dead or to the gods. They contained especially the canonic oils, which were seven or nine in number. Vincent Crespi states that a similar object was found in Sardinia. It is a hollow disk carrying seven cups, with a ram's head in the middle; it seemed to represent a seven-branched lamp. According to him, the number of cups, seven, which is often found in Egyptian tombs, indicates the seven planets. Admitting this conjecture, the ram's head represents Jupiter Ammon, accompanied by the seven planets to whom the lamp was dedicated. The analogy of this object to the seven-branched candlestick of the Hebrews is at once apparent.

BLACK VASES DUG UP ON THE SITE OF CARTHAGE.

In another tomb was found a terra-cotta object which is worthy of special mention. It has the form of a winged Sphinx. This curious piece is 12 inches long and 13 inches high and rests upon a rectangular base. It will be observed in the engraving. The body, with short legs and strong muscles, is that of a lion. It is covered with scales and has a pair of wings. The head is a human face. The visage is painted red, with the pupils and eyebrows in black. The headdress, also in red, resembles the Egyptian *pschent* in its form. Two symmetrical masses frame the face, neck, and breast, and are painted black, as well as the tiara above. The tiara has a small hole in the top and two others on the sides, no doubt for fixing ornaments. The neck and breast are ornamented with necklaces traced with a point before baking. The wings are curved backward, and between them is a cylindrical or pipe-like projection. In front of the breast projects a horizontal cylinder with a circular hole, making the whole a kind of recipient for liquids. The general tone is in red, with black markings on the wings, claws, and scales. This winged sphinx, having the bust of a man, a lion's body and legs, an eagle's wings (perhaps the scales of a fish), offers an analogy to the Assyrian *nirgalli*. The special form of this object will also recall the winged Cherubim of the Bible.

The Carthaginian system of weights and measures can be reconstructed from the objects found in the tombs. Many different forms of weights were brought up. One set contained the two plates of a balance and nine lead weights of truncated pyramid form, ranging from 188.6 to 9.12 grammes. Another set were of a greenish lithographic stone, and well polished, while a third set were of bronze, filled with lead in the center.

EXTRAORDINARY PHENOMENA OF N-RAYS.

The latest of the various types of radiations discovered and studied during recent years—namely, the N-rays and the N[1]-rays—have developed most peculiar properties, some of which perhaps are capable of being utilized for practical purposes. Thus it has been found that certain chemical reactions are always accompanied by the emission of N-rays, while in other reactions, which from a chemical point of view are very similar, no N-rays appear. There appears to be no parallelism whatever between the process activity of the chemical reaction and the N-ray effect, and for this reason a study of the emission of N-rays might enable one to recognize the existence of a certain reaction otherwise masked. Some very interesting biological effects have recently been studied by several French savants with reference more particularly to the variation in the emission of N-rays from the brain of an animal while under narcosis, and to analogous experiments with inanimate substances, like metals. For example, M. Edouard Meyer has found that plants cease emitting N-rays when subjected to the influence of chloroform; and M. Jean Becquerel later found that the same effect may be observed with inorganic sources of N-rays, like calcium sulphide, which, when exposed to vapors of chloroform or ether, cease entirely to emit N-rays.

The question having presented itself, What would be the effect on the nerve centers of animals under the influence of anæsthetics? some experiments along this line were made by MM. Jean Becquerel and André Broca and reported to the French Academy of Sciences on May 24. They subjected dogs to the action of vapors of ether and chloroform and studied the emission of N-rays from the brain substance and from the spinal marrow during the several stages of the experiment. The different narcotic substances have somewhat different effects in detail, but in general the effect is as follows: In the state of high excitement which precedes the stage of narcosis, the brain emits N-rays in enormous quantities. They may be easily observed by means of the decreasing brightness of a calcium sulphide screen, fixed at the end of a lead tube and passed over the brain fissure. When the subject reaches the real stage of narcosis, the phenomena change, the brain no longer emits N-rays and later on N[1]-rays appear. The latter are recognized from the fact that the brightness of the sensitive screen, when handled in the same way as before, now increases. It was found that the radiation from the spinal marrow undergoes much smaller variations than that from the brain. The spinal marrow can be studied with great ease on account of the centers of radioactivity existing in it, as located recently by Broca and Zimmern. Here the changes in the emission of N-rays are small, and even after respiration and the activity of the heart have ceased, the rays continue to be emitted from the spinal marrow for about half an hour. The absolute cessation of radiation from the nerve centers for several minutes is a sure sign of death.

In a later note presented by M. Jean Becquerel to the French Academy, other and still more singular observations are recorded. Aluminium and copper are transparent to N-rays, but this transparency ceases as soon as the surface of the metals is subjected to the action of the anæsthetics. On the other hand, glass and wood continue to let the rays pass. Moreover, a metal emitting rays from its total mass, like steel or copper in compressed or elongated condition, ceases emitting rays if its surface is subjected to the influence of anæsthetics, while compressed wood does not seem sensible to the action of chloroform or ether. All these facts emphasize the great complexity of the phenomena. Whether, however, the results observed are due to the anæsthetic properties of the liquids used, or to other properties they possess, the report referred to leaves us in doubt. Before it can be safely assumed that inanimate substances are affected by anæsthetics as such, very positive proof will have to be presented. M. Becquerel has attempted to analyze the nature of the molecular vibrations to which he attributed the origin of N-rays and N[1]-rays. He distinguishes two different vibrations: First, undulations like those of

light waves, which pass through aluminium with a speed comparable with that of light through glass; second, another form of energy which passes through aluminium very slowly and the transmission of which may be arrested at the surface of metals under the influence of anæsthetics.

Further investigation of these extraordinary phenomena will be awaited with interest. The history of the development of our knowledge of radiations is most interesting and peculiar in several respects. It is peculiar that the different kinds of radiation, some of which we now know to be nearly everywhere present, have been overlooked until quite recently, and their intimate study appears likely to remove some of the distinctions between different branches of science, while practical applications of their properties have already been made. We know, for example, that Röntgen rays are useful in medicine and surgery, and radioactivity has recently been applied to the measurement of capacities. Moreover, nothing has contributed more to the development of the electron hypothesis than the study of cathodic rays, and it is not improbable that further investigation will furnish material for a wholly new foundation for the sciences of physics and chemistry. Even more interesting is that, in view of the results from the study of N-rays, we may at least hope that bridging the gap between animate and inanimate nature will not forever remain a mere dream of the speculative mind.—Electrical World and Engineer.

RESULTS OF BORAX EXPERIMENTS.*

By Dr. H. W. Wiley.

The work of which the following digest is presented was undertaken in accordance with the authority conferred by Congress upon the Secretary of Agriculture to investigate the influence of various substances added to foods upon health and digestion. The exact wording of the act is as follows:

"To investigate the character of proposed food preservatives and coloring matters to determine their relation to digestion and health and to establish principles which should guide their use."

The necessity for an investigation of this kind is found in the very general use of certain chemical compounds for preserving foods, and also in the very common use of certain coloring matters for imparting to foods a tint resembling that of nature, which the foods may have lost, or of producing certain colors in food products which are attractive to the eye of the consumer.

The use of preservatives in food products is as old as civilization, and there is no occasion in these investigations for extending the scope of the authority given to the study of the long-established preservative agents. Moreover, these preservative agents which have been so long in use are condimentary in character and reveal themselves at once by taste or odor to the consumer. The more important of these common and long-established preservatives are salt, sugar, vinegar, and wood smoke. Alcohol has also been long used as a food preservative, but does not rank in antiquity and in generality of use with those just mentioned.

One of the chief characteristics of the modern chemical preservative is that it is often almost without taste or odor, and for this reason its presence in a food product, unless specifically proclaimed, would not be noticed by the consumer. But while this is true of most of the preservatives used in the preparation of foods (except the condimental substances mentioned) in the quantities employed, this does not mean that in a concentrated form they have neither taste nor odor. Quite the contrary is true. Nearly all of them in a concentrated state reveal themselves either by taste or by odor. For instance, salicylic acid in a pure state is easily distinguished by the taste, and sulphurous acid in the form of gas or in a nearly saturated solution is distinguished by its odor and irritant effect upon the nostrils. Nevertheless small quantities of salicylic acid can be placed in food products without the consumer being able to detect it, and the same is true of sulphurous acid.

Legislation of various kinds in different countries and in the different States† of the United States has been enacted concerning the use of preservatives and coloring matters in foods. This legislation is of varying character, prohibiting in some countries what is allowed in others, establishing rules and regulations which are local in character, and, in general, producing a state of affairs which is annoying to the manufacturer of food products and the dealers therein, and which, by the diversity of laws and decisions relating thereto, does not secure to the consumer the full benefit which was intended. The desirability of some investigation, therefore, was apparent, in order to establish certain principles concerning the use or prohibition of these substances, which, by reason of their more general applicability, may influence local and general legislation in a matter tending to secure a greater uniformity and efficiency. It is also evident that if these investigations could be conducted under some direction not particularly interested in the construction of any law, nor associated in any commercial way with the interests of either manufacturer or consumer, they would have a greater weight.

The Secretary of Agriculture is manifestly the proper official to undertake and direct such an investigation. The interests of the department over which he presides are associated alike with producers, manufacturers, and consumers of food products, and thus any bias which might exist in other quarters in favor of any particular interest would be eliminated. For this reason investigations conducted under his direction, even if no more thorough, painstaking, or reliable than if carried on under other auspices, would be commended more generally by reason of their freedom from influences which might tend to divert them from their intended purposes.

PLAN OF THE INVESTIGATION.

In determining the method by which these investigations should be conducted a careful study was made of similar researches carried on under other auspices, both in this and in foreign countries. A survey of the field of research in this direction shows that three principal methods of procedure have been followed.

In the first case may be cited those investigations which have been conducted by means of artificial digestion. Fortunately for science, the various ferments which are active in digestion in the living animal have been isolated and prepared in a reasonably pure state. By securing as nearly as possible the other conditions which obtain during digestion in the living body, artificial digestion similar thereto can be secured. Thus if food properly comminuted and kept at the temperature of the stomach, in motion similar to that produced by the peristaltic action of the intestines, be treated by the proper digestive acids and ferments, the chemical actions which occur are entirely similar to those which take place in the living organ itself. Thus the ferments which digest starch and sugar, those that act upon protein, and those that act upon fats can be studied without the living organism. The results which have been obtained by this method of investigation are most valuable, and when the preservatives and coloring matters in question are added, any changes which are produced, either in the degree or in the rate of digestion, can be easily ascertained.

In the second case the problem may be studied by experiments conducted upon the lower animals, and from the results of these experiments inferences may be drawn applicable to the human animal. This line of experiment and investigation has also great merit. The animals operated upon are kept under close control. The amount of food which they consume is easily ascertained. The excreta they produce are collected, and a complete chemical control can be instituted in connection with the digestive process. When preservatives and coloring matters are added to the food of animals thus treated, any changes which take place in the digestive processes or any lesions which are produced in the organs of the body can be ascertained. This method of investigation also has the additional merit that at the end of the period of observation the animal may be killed, and changes in its organs, which were so slight as to produce no observable effects during life, may be sought and discovered. Thus, minute or incipient lesions of the digestive organs, or of the other organs of the body, are brought to light which otherwise would escape notice. If the digestive processes in the lower animals were exactly the same as those in the human animal this method of investigation would necessarily be accepted as final and conclusive; but each species of animal has its own peculiarities of digestion, and, therefore, the results produced on one species of animal by a certain course of treatment might not be secured with an animal of a different species or genus. This fact has led investigators to undertake a third kind of research, namely, experiments with the human animal itself.

This method of investigation also has advantages as well as many disadvantages. For the most part, such investigations are carried out upon volunteers, since no one could be forced to undergo any such experimental treatment except as a punishment for crime. In the second place the intelligence of the human animal may also be utilized in the study of the effects produced. Symptoms which the lower animals might have of distress or malaise, when in the incipient stage, might escape notice altogether, whereas similar symptoms in a man would be described. Further, it must be admitted that animals under confinement, as is necessarily the case when experiments are made with them, are not wholly in a normal state, whereas the man who volunteers for an experiment of this kind would not chafe or become restive under confinement. Again, it must be considered that as the object of the investigations above outlined is necessarily applicable to the digestion and health of man, it is evident that the experiments made upon man would be the most decisive in all cases.

The one great disadvantage of experiments of this kind is the inability to absolutely control the experimentee. Where a large number of persons is to be considered and the experiment is to extend over a long period, it is evidently impracticable to secure a direct personal control of every action of each one during the whole time. In the present case the young men selected, who volunteered for the experiment, continued their usual vocations. They were simply placed upon their honor and neither watched nor confined. The data which are obtained in this way are, therefore, open to the objection, in some cases, that the rules and regulations set for the conduct of the experiment may have been transgressed without the knowledge and consent of the observer. While this is a valid objection and should have full consideration, it must not be forgotten that among the twelve young men upon whom the experiments were conducted, it is not likely that the violations of their pledge of honor would be sufficiently numerous to affect in any marked degree the results as a whole. Further, it must be remembered that the greater number of those upon whom experiments were made were young men of approved character, many of them had college training, and a large majority of them were engaged in scientific pursuits. All these facts are of more or less importance in considering the character of the data secured. It would be unwise to claim that among so many persons, and amid so many temptations, no violation of the pledge took place, yet it must be admitted that upon the whole we can be reasonably certain that the obligations voluntarily assumed were discharged faithfully and conscientiously. Any departures from the set rules of conduct which might occur would not be made with any design of affecting the data, and, therefore, as a whole, the errors which might arise from this source would, according to the doctrine of probabilities, be largely compensatory. Thus, while in any individual case the data might be rendered unreliable by reason of such departures from the set rules, the results as a whole would not be seriously affected. The plan of the work, therefore, included the idea of conducting the investigation with volunteers—young men, most of whom were connected with the Department of Agriculture—and provided that during the period of observation they should continue in their usual vocations.

DETAILS OF ORGANIZATION OF THE WORK.

Control of Subjects.

A large number of volunteers offered their services for the investigations above outlined, from whom twelve were selected. Each applicant was required to fill in a blank describing the usual conduct of his daily life. This blank is as follows:

Descriptive blank to be filled out by applicants for Hygienic Table.

1. Name and address.
2. Date of birth.
3. Have you had any sickness confining you to your room within a year? If so, state nature and duration.
4. Are you subject to indigestion? If so, state character and frequency.
5. Do you use coffee, tea, or chocolate with your meals? If so, state at which meals and which beverage you prefer.
6. Do you use tobacco? If so, state in what form, at what times, and quantity.
7. Do you use wine, beer, or other alcoholic beverages?
8. Do you go to stool regularly? At what hours?
9. At what hours do you usually urinate?
10. At what hours do you go to bed? How many hours do you usually sleep?
11. Do you engage in any unusual or violent exercise? If so, what?

All applicants who were addicted to the use of alcoholic beverages were excluded for the reason that alcohol, having a certain food value, and the habit of using it often being a strong one, the difficulty of refraining from its use would at times become very great. Moreover, it was desired not to complicate the character of the diet by the introduction of any alcoholic beverage. Applicants addicted to the moderate use of tobacco were accepted on condition that a statement be made covering the usual quantities of tobacco consumed, the character thereof, and the methods of consumption. Such applicants were admitted to the hygienic table agreeing, among other things, to continue the use of tobacco regularly during the whole period in the manner described. The members of the table having been selected, each one was required to subscribe to the following pledge:

"I hereby agree, on my honor, to follow implicitly the rules and regulations governing the hygienic table of the Bureau of Chemistry during the time that I am a member thereof. I agree, during my attendance at the table of observation, to use no other food or drink than that which is provided for me, with the exception of water, and that any water not used at the table will be measured and reported daily as a part of the ration. I further agree that I will continue to be a member of the hygienic table for a period of at least six months, from December 1, 1902, unless prevented by some illness, accident, or unavoidable absence. I agree to continue the regular habits of my life, to indulge in no unusual excess of labor or exercise, and if tobacco be used it shall be used at such times and in such amounts as will be agreed upon between myself and the chief of the Bureau of Chemistry.

"I further agree that I will not hold the Department of Agriculture, nor any person connected therewith, responsible for any illness or accident that may occur during my connection with the hygienic table."

In experiments of this kind it is evident that it is necessary to rely to a certain extent upon the honor of the person under observation. The only other method would be to exercise continued surveillance day and night, which, under the circumstances of these experiments, was quite impracticable. At the completion of an experimental period, in retiring from the experimental table and passing to the recreation table, the candidate was required to subscribe to the following certificate:

"I hereby certify on my honor that during the period beginning .... and ending ...., I have not partaken of any food or drink (except water reported) other than that furnished at the hygienic table of the Bureau of Chemistry, and that I have accurately recorded all the items of food and drink received at the table.

"I further certify that I have not engaged in any excessive or unusual physical exercise; that I have followed, in so far as possible, the regular tenor of my daily life in respect of work, exercise, and sleep; that I have observed to the best of my ability and recorded accurately the data relating to weight, temperature and

* Digest of Bulletin No. 84, giving the plan of work and conclusions as to effects of boric acid and borax on digestion and health.

† U. S. Dept. of Agr., Bureau of Chemistry, Bul. 69, Parts I-VI: Bul. 83, Part I.

pulse; and that I have observed faithfully all the regulations connected with the experimental work at the hygienic table."

By thus placing the young men on their honor, by interesting them in the work, and by giving them periods of rest during which they were at liberty to eat moderately at other tables than those set in the Bureau of Chemistry, practically the same results which would have been obtained by an absolute control of animals experimented upon both during the periods of eating and the intervening periods were secured.

Hours of Meals.

The hours of meals were fixed as follows: Breakfast, 8 A. M.; luncheon, 12 M.; dinner, 5.30 P. M. The members of the table were urged to be as prompt as possible at meals, although in certain circumstances some latitude was allowed. Inasmuch, however, as the food had to be weighed in advance of the meal time, it was desirable that all should be present promptly at the hour in order that the food should not grow cold or stale. It perhaps would have been desirable to extend the meals over a longer period had it been convenient, since the arrangement above described made a very long interval between the dinner, which was finished usually by a quarter past six, and the breakfast of the next morning—in all about fourteen hours during which no food could be taken—while, on the other hand, all of the meals were included within a space of about ten hours. An earlier breakfast, say at 7 o'clock, and a later dinner would have been desirable, but the employment of the young men and other conditions of the environment, made any different arrangement from that adopted inconvenient to the majority of those under observation. Further than this it should be mentioned that the hours selected for the meals were those which are customary for those who are engaged in the civil service of the United States. For this additional reason it perhaps was wiser not to attempt to change the hours of meals in order to avoid having so long a period between the dinner and the breakfast.

The breakfast and dinner were made the principal meals, while the luncheon was of a lighter character, no meat being served.

The Bill of Fare.

Since the young men were to be kept under observation for periods of from 30 to 70 days, it was clearly desirable to make the bill of fare as varied as convenient. To this end the meats selected were roast beef, beefsteak, lamb, veal, pork, chicken, and turkey. Fish and oysters were also used. The eggs which were served twice a week, may also be included with the meats. The butter was of the best quality which could be made, and was free from coloring matter and salt. The milk and cream were obtained from dairies carefully inspected by the authorities of the District of Columbia and personally visited by the chief of the Bureau of Chemistry. The vegetables were those of the season, and where they could not be obtained otherwise, the best grades of vegetables preserved by sterilization alone were used. The soups, in order to secure uniformity in their composition, were purchased of large manufacturing firms making a specialty of soups. The fruits were those of the season or preserved without antiseptics. In all cases it was stipulated that none of the foods furnished should be treated with any preservative, and in no case was this injunction violated, in so far as our examinations extended. All the preserved foods which were employed had either been kept in cold storage, as was the case of the meats and the fowls, or been subjected to sterilization and subsequent exclusion of the air, as was the case with some of the vegetables, fruits, and soups. Assurances that these bodies were free from any chemical preservative or other antiseptic were secured from all the dealers, and the assurances were confirmed by our own examinations. Coffee and tea were allowed in moderate, uniform quantities to those who were in the habit of drinking these beverages. Desserts of various kinds were employed at regular times, consisting of custards, rice pudding, and ice cream made with the best cream, sugar, and a flavoring substance. A liberal supply of fruits was incorporated with the food supply, either those in season or those preserved by sterilization.

The bill of fare was varied every day, but recurred regularly in seven-day periods. This arrangement avoided the monotony of eating the same character of food on successive days, and, at the same time, favored simplicity, both for the cook and for the steward, to guide in the one case in the methods of preparation of the food, and, in the other, to determine the character of the supplies to be purchased.

Two rooms in the basement of the laboratory building were equipped as kitchen and dining room respectively. The kitchen was supplied with two gas ranges and a full supply of culinary utensils. The dining room was plainly, yet substantially, furnished with the necessary articles for preparing a table in a neat, attractive, but not expensive manner.

Series and Periods of Observation.

Three divisions were made of each series of observations, namely, fore period, preservative period, and after period. The time assigned to each of these periods varied, and the total time of the three periods varied from 30 to 70 days.

During the entire time of observation the rations of each member of the table were carefully weighed or measured, and the excreta collected.

The object of the "fore period" was to determine as nearly as possible the quantity of food required to maintain the body weight at nearly a constant figure, and to determine the normal metabolism as a basis of comparison with that of the preservative period. Preceding the fore period the quantities of food freely chosen by each individual were noted, so that some idea might be formed of the proper amount to be weighed or measured. If it was evident that too much food had been habitually consumed, keeping the body in a plethoric state, the rations were cut down somewhat in order that this condition might be removed. The quantity of the ration was, therefore, varied either by increase or decrease, until at the end of about ten days there was no very marked daily change in weight. It was found impracticable, however, to secure an absolute constancy of body weight, since the climatic conditions, slight differences in the amount of exercise, and variations in the quantity of excreta all combined to produce variations in weight (ascertained at any given period of the day), which are more or less independent of the actual quantity of food consumed. In order that these daily variations may be eliminated from consideration in the comparison of data, the average weight for the "fore period" is taken as the initial point.

The quantity of the ration having been thus determined by the observations of the "fore period" the "preservative period" is entered upon. During this time the quantity of ration previously determined is given without variation, except in case of sickness or some unavoidable condition, and to this ration a certain quantity of the preservative to be studied is added.

Borax was selected as the first preservative to be experimented with, both because it is probably the most important of the commonly used preservatives and also because it lends itself to purposes of demonstration the most readily. The preservative was exhibited in two forms, namely, borax and boric acid, as it was thought possible that the soda entering into the former might produce some modification of the results.

During the first part of the experiments here described, the borax or boric acid was mixed with the butter. In later periods of the study it was deemed advisable, for many reasons, to administer the preservative in capsules. When it was realized that a certain article of food contained the preservative a natural distaste for this article was developed, due largely, perhaps, to mental attitude. Since it was known by all that preservatives were administered, there seemed to be no valid reason why they should not be given in capsules in order that the prejudice against any particular article of food might be avoided. It is true that objection might be made to this method because it is so different from the actual method of consuming preservatives when added to foods in the ordinary way. Preliminary experiments with the gelatine of the capsules showed that it dissolved in a very few moments in the digestive ferments. This having been established, it is evident that in a few minutes after the administration of a capsule containing borax its gelatinous envelope would be dissolved, and by the peristaltic action of the stomach the contents of the capsule would be mixed with that of the stomach. It is hardly necessary to add that the food value of the capsule in each case was determined and allowed for in making the balance of the daily rations.

In the administration of the preservative, small quantities were first given, approximately as much as would be consumed in eating foods preserved with borax, such as butter and meat. These quantities were progressively increased for the purpose of reaching, if possible, the limit of toleration of the preservative by each individual. For each variation of the quantity given a separate study of the digestive processes as influenced by the preservative was made.

At the end of the preservative period, the after period began. During the after period practically the same quantities of food were given as in the preservative period, the preservative, however, being omitted. The object of this after period was to restore the individual as nearly as possible, if there had been any disturbance of his physical state, to the condition precedent to the beginning of the experimental period.

During the entire time from the beginning of the fore period to the end of the after period the foods were weighed or measured and analyzed, and the excreta collected and analyzed.

(To be continued.)

THE ELECTRO-METALLURGY OF IRON AND STEEL.*

By EMILE GUARINI.

TWENTY-FIVE years have elapsed since the invention of the Siemens furnace, and only now electricity is beginning to be used for melting metals, especially iron and steel. A priori, it would be impossible to explain why electricity, which has almost completely supplanted in many instances other sources of power, such as steam, compressed air and water under pressure, has taken so long a time to replace the other sources of heat necessary for the production of high temperatures for the melting of iron and steel. The reason is, however, that in every industrial problem there are two very distinct phases, which must never be confounded—the scientific and the commercial. As long ago as 1879, William Siemens demonstrated that it would be possible to melt metals with electricity, and pointed out the fact that the only question to be answered was that of net cost, and that for the solution of this problem it was not a matter solely of solving purely technical questions, but mainly the question of the cost of the energy, which was then very high. At present, with the low cost of electricity and especially the improvement in technics, things have an entirely different aspect, and, for the electro-metallurgy of iron and steel, we can already foresee a very brilliant future. The electric process, in fact, renders it possible to obtain superior quality of steel which it would be difficult, and perhaps impossible to obtain otherwise. It happens, moreover, as in every invention, that those who, for one reason or another, are interested in the old process, are trying by every means possible, to discredit the new electric process. What is more interesting still is that every inventor of a system has very severe criticisms to make of the systems of other inventors, so that taking such criticisms as a whole, we might draw the conclusion that none of the systems is good. The object of the present article is, as far as possible, to bring some order out of this chaos.

Contrary to what has usually been written, it may be stated that it is not possible to give a general rule for establishing the fact that ordinary metallurgy excels electric metallurgy from the viewpoint of net cost. This cost is very variable in both methods, not only according to the system employed, but also in different countries. As regards systems, it is evident that the most improved will be chosen, and it must be remarked that one system may be more advantageous than another according to local circumstances. There are, on the other hand, countries such as Italy and Switzerland, in which hydraulic power is exceedingly abundant, and on the contrary fuel is exceedingly scarce. It is evident that in such cases we can say that as a general rule the application of electricity is more advantageous. The advantage will be still more marked in countries in which iron mines are situated in the vicinity of hydraulic power, especially if fuel is dear. Another case in which electricity is indicated is that in which it is desired to enlarge metallurgic works already equipped with ordinary blast furnaces. Such works will then utilize the waste gas for the production of electricity, which, in turn, will serve for supplying an electric furnace for special steels or even for ordinary steel, if the quantity of energy be adequate. In countries very rich in fuel and poor in hydraulic power, the establishment of new furnaces operated by electricity, as well as the replacing of existing furnaces by electric ones, cannot be recommended as economical, at least in the face of the results obtained by the electric steel works already installed. On this subject, it may be stated, however, that as yet there have been constructed no electric furnaces as large as the coke blast ones in which is obtained that low cost of production with which we are so familiar.

Another circumstance that pleads in favor of electricity is that while blast furnaces have reached their maximum of perfection, electric ones are in their infancy, and the electric method is ever making progress toward a decrease in the cost of production.

In the apparatus now employed in metallurgy, the utilization of the calorific energy scarcely exceeds, as a general rule, from 18 to 20 per cent, and it is only in the most improved systems, especially the cupola and hot air blast furnaces, that from 30 to 50 per cent is reached. In electric furnaces, on the contrary, 80 per cent is attained, and in large works there is nothing to prevent an average of nearly 100 per cent being obtained.

The existing electric furnaces may be divided into three great classes, each having its advantages and disadvantages that may decide the choice of one or the other according to circumstances: (1) arc furnaces; (2) resistance furnaces; and (3) induction furnaces.

The arc process consists in raising the metals to fusion through the heat of the voltaic arc. There are two principal types, one in which one of the electrodes consists of the metal to be melted, and the other of an electrode suspended beneath this metal, and another in which is employed a complete arc with two electrodes independent of the metal to be melted. The objection has been made to this system that it has many inconveniences: the preliminary crushing and admixture of the ore with the coke and flux, the excessive tension necessary for the production of the arc, the extremely high temperature and the difficulty of regulating it, the incorporation of the impurities of the electrodes with the steel, the injurious effect of the carbon monoxide disengaged by the arc upon the quality of the steel, and finally the want of uniformity of the heat in the various parts of the furnace. The latter inconvenience, however, has been remedied by multiplying the number of the arcs and the use of reverberations.

In the resistance furnaces the Joule effect is utilized. There are two types: (1) that in which the material itself serves as a resistant conductor; and (2) that in which independent resistances, usually of carbon, are raised to incandescence and communicate the heat to the metal to be melted. The resistance system is the one that has been the subject of most study. We are, however, far from believing that it is the most improved one. It has its advantages, but also many defects. As an advantage we may mention the doing away with a preliminary crushing and mixing of the ore with the coke and flux, the weaker tension of the electric current, the possibility of regulating the temperature at will, and the possibility of employing great units, since it is necessary only to increase the tension in proportion to the length of the resistances. One of the objections that may be made to the systems that utilize the material itself as a heating resistance, is that the resistance varies with the temperature of the metal to be melted, and that the intensity of the

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

current consequently varies also. Since, moreover, the resistance of the material is quite weak, it requires great current intensities, and hence cables of large cross-section. For this reason the independent resistance systems have been devised, covering or covered by the material to be fused or in fusion.

In order that the variations in the resistance of the matter in fusion shall not produce appreciable variations in the intensity of the current, the resistance of the supplementary resistances must be very great with respect to that of the matter in fusion. But, if such resistances are very great, considerable tension is requisite, and we then encounter one of the drawbacks of the arc system. This system has likewise some inconveniences of a secondary rank upon which we shall not dwell.

(To be continued.)

RACING AUTOMOBILES IN THE 1904 GORDON BENNETT CUP RACE.—II.

By the Paris Correspondent of the Scientific American.

An entirely new form of four-cylinder motor has been designed for the Mors racing cars. It differs considerably from the motor which is used on the standard cars of this make. The details of the new motor have not as yet been made public, but one of the novel points of construction lies in the position of the crankshaft, which is now carried considerably to one side of the axis of the motor cylinders. This disposition is adopted in order to diminish the obliquity of the piston rods during the period of explosion and descent of the piston. It is found to increase the efficiency of the motor to a considerable extent, and, on the other hand, it diminishes the vibration which the motor gives to the chassis. Each of the four cylinders of the new motor, together with its valve-chamber, is formed of a single steel casting with a complete absence of joints, which is a great advantage as regards solidity and tightness.

The carbureter used in the racing cars is of the new type, which was brought out not long ago. It has been found to work very satisfactorily. Its operation will be understood from the sectional view, Fig. 1. In order to secure the good working of the motor, it is necessary to supply it with the proper mixture of gas and the proper quantity for the speed at which it is desired the motor shall run. These desiderata are easily obtained with the new carbureter. It is composed of a cylindrical body, *A*, into which is fitted the tubular piece, *B*, at the lower part. The gasoline enters through the atomizing tube, *C*, which is placed in the center of *B*. The gasoline feed is controlled as usual by a float-feed chamber. At *D* is an inlet for the air which passes through *B*, and an additional supply of air can be admitted to the carbureter through an automatic valve, *m*, placed in a chamber at the left. This valve admits air into the annular space which surrounds the end of the tube, *B*. The operation is as follows: The chauffeur, by regulating the position of the throttle, *G*, which is placed in the upper part of the carbureter, can control the inlet of gas to the motor. When the motor is running at slow speeds, the air enters only by the orifice, *D*, and the chamber, *B*. When it is desired to increase the speed of the motor, the throttle, *G*, is opened gradually and increases the delivery of gas. As the gas now finds a larger passage to the motor, the partial vacuum in the chamber *A* increases, and it becomes sufficiently strong to operate the valve, *m*, against its spring. An additional supply of air is thus admitted through the valve into the space, *A*, and the carbureted air coming from *B* is mixed with it. The more the throttle, *G*, is opened, the greater becomes the speed of the motor, and at the same time the quantity of air which is admitted through the valve, *m*, is also increased, so that by this means a good carburetion is always secured at the varying speeds of the motor. The design of the carbureter is carried out so that at each different speed of the motor the best amount of suction is obtained in the chamber. The mixture is always kept at the proper temperature and is heated by a water circulation through the water jacket, *E*, surrounding the upper part of the chamber. Hot water from the motor water-circulating system is sent through the jacket.

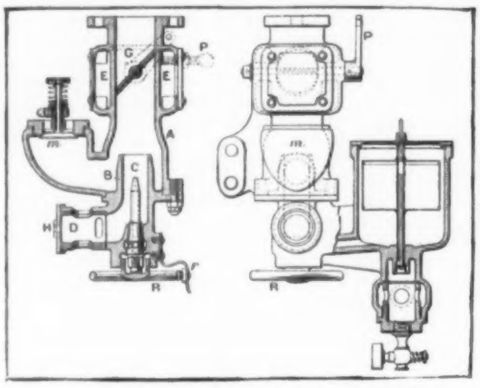


Fig. 1.—THE NEW MORS AUTOMATIC CARBURETER.

The carbureter can also be regulated for different atmospheric conditions by changing the orifice of the air inlet. This is carried out by turning the cylinder at *D* and opening or closing it as required.

The Mors cars use the system of magneto ignition, combined with mechanical make-and-break igniters operated from the same cam shaft that works the valves. By displacing the handle on a notched sector the chauffeur can shift the ignition point at will. Current is furnished by a magneto of special design, which is operated by gearing from the motor. To reduce the wear of the parts and also diminish the noise, the number of revolutions of the magneto is now reduced so as to equal that of the motor.

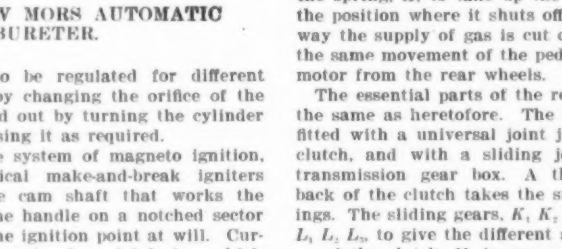
so as to increase the speed of the motor. On releasing the lever, the opposing spring, *A*, tends to shut off the gas.

In order to bring the motor up to a high speed during a short time without changing the adjustment of the former lever upon its sector, a second device known as an "accelerator" is employed. This consists of a pedal, which is connected by a second cable, *L*, with the throttle lever, *D*, of the carbureter. By pressing on the pedal, the gas inlet is opened quickly and the motor brought up to full speed. On releasing the pedal, the motor drops back to its former speed. This device has been found of great advantage in running the car.

Another new device is the method of uncoupling the motor. This works with great ease and diminishes the noise considerably. Referring to Fig. 2, the cable, *K*, is attached to the two ends of the levers, *C* and *D*, and passes over the pulley, *M*. The latter is fixed to the pedal which throws off the friction clutch and uncouples the motor from the rear shaft. As the length of the cable is constant, the locus of the different positions of the point *M* (when the cable preserves its length) is the ellipse $x\ y$, Fig. 3, with *C* and *D* as foci. However, by pressing on the pedal, *J*, the pulley, *M*, describes an arc of a circle, *MN*. As the arc lies on the interior of the ellipse, the length of *CND* is now diminished and the cable hangs loose. This allows the spring, *A*, to take up the slack and come back to the position where it shuts off the carbureter. In this way the supply of gas is cut off from the cylinders by the same movement of the pedal which disconnects the motor from the rear wheels.

The essential parts of the rear mechanism are much the same as heretofore. The transmission shaft, *S*, is fitted with a universal joint just back of the flywheel clutch, and with a sliding joint where it joins the transmission gear box. A thrust ball-bearing fitted back of the clutch takes the strain off the motor bearings. The sliding gears, K_1 K_2 K_3, work with the gears, L_1 L_2 L_3, to give the different speeds as usual. At full speed the clutch, *M*, is engaged with *N* and the bevel gearing, *C J*, drives the differential. This secures the direct drive from the motor to the rear.

There are two sets of bevel gears for driving the differential countershaft. Of these, one bevel gear is



Figs. 2 and 3.—DIAGRAMS SHOWING CONNECTIONS OF PEDALS WITH CARBURETER AND THEIR EFFECT.

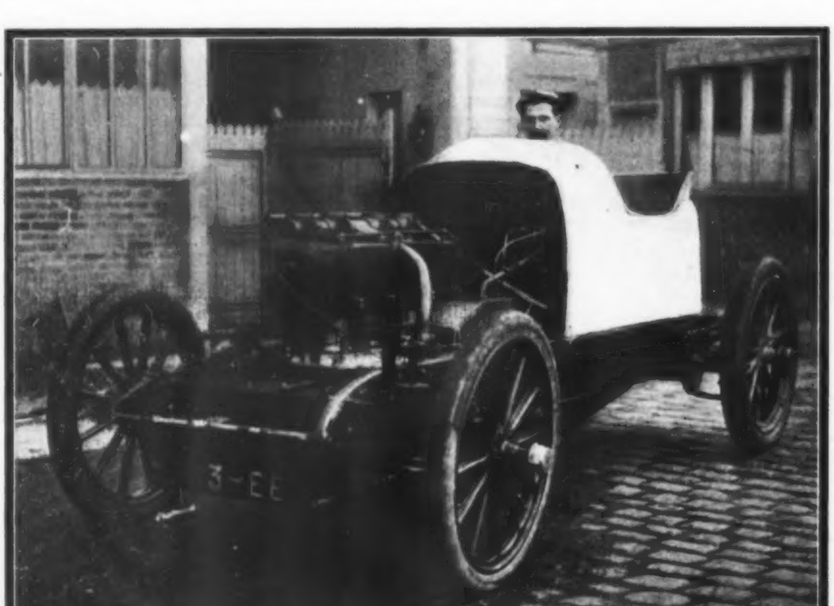
The variation of the motor speed is obtained by operating the throttle valve from the carbureter to the motor, as has been observed. The valve is operated by a lever which is normally held in the shut-off position by a spring. Its movement is controlled by a hand lever mounted upon the steering wheel (Fig. 3). The hand lever is connected by a rod which passes down through the hollow shaft of the steering wheel with the lower lever, *C*. To the end of the latter is connected a steel cable, *K*, and the other end of the cable is joined to the throttle lever on the carbureter, passing over the pulley, *M*. When the chauffeur acts on the hand lever, *B*, he pulls on the cable and opens against the spring, *A*, the throttle of the carbureter,

on the secondary, or lay shaft, of the transmission for use with the gears of this shaft, on the first, second, and third speeds. The other driving bevel gear is used only on the fourth or high speed, when a direct drive is employed, the bevel being locked to the sliding gear by a jaw clutch.

The Belgian cars which entered the races are of the Pipe system, built by the Compagnie Belge de Construction d'Automobiles. The photograph shows the appearance of the new racing cars, which are somewhat torpedo-shaped, rounded at the back and terminating in a sharp edge in front. The present car is mounted by L. Hautvast. One of the leading peculiarities of the Pipe system is the use of a magnetic friction clutch for connecting the front and rear mechanism. In the front of the car is a four-cylinder motor and next it lies the magnetic clutch; after this comes a shaft which passes to the speed-changing box. The rear wheels of the car are driven from the differential shaft by chain and sprocket wheel.

The magnetic friction clutch, which has been described in a preceding article (see Supplement No. 1466, February 6, 1904), is formed of a group of flat plates or disks of soft iron, one of which carries a magnetizing coil; and by sending current into the coil, the disks are brought together and act as a clutch. One disk is mounted on the motor shaft and a second on the rear shaft of the car. In this way the latter can be coupled or uncoupled by simply operating a switch. In practice a set of resistance coils is placed in the circuit so as to effect the movement gradually. Since it was first brought out, the new system has had a thorough test, and the good performance of the cars in the cup race is another point in its favor. When the car is started, slowed up, or passes over a hard place in the road the driver, by properly operating a pedal, can let the clutch slide or grip as desired without causing an abnormal heating. This gives a flexibility to the movement of the car. At the same time the apparatus is extremely light as well as strong and it does not need to be regulated. Contrary to the usual forms, it does not exert a pressure upon the motor bearings, seeing that it has no internal spring. The driver works it with much less fatigue than usual, seeing that the force which operates it is entirely magnetic, and the pedal has only a very light spring, just sufficient to bring it back to position.

The motor of the Pipe cars has four vertical cylinders mounted in pairs. It is designed for 100 horse-



THE 100-HORSE-POWER MORS RACER, WHICH FINISHED SEVENTH.

power. The inlet and exhaust valves lie on the same side of the motor and are operated by a single camshaft. The latter is provided with a device for relieving the compression of the motor when starting up. The gas inlet from the carbureter to the motor is regulated by a throttle valve upon the former. The ignition is carried out in the usual way by accumulators, induction coil, and spark plug. The position of the radiator, placed in front and underneath the chassis, will be observed. The front and rear wheels are of equal diameter. The motor and transmission mechanism are protected by a casing which passes along underneath the whole length of the car. Steel and wood are used in the construction of the car frame. The speed-changing gears, which are contained along with the differential in an aluminium case, allow four speeds of the car and a reverse. The brake, which is mounted on the differential, is entirely metallic and is formed of two semi-cylindrical brake-shoes working inside a cylinder. A similar set of brakes are mounted on the rear wheels, and are entirely inclosed in a tight case.

Mr. S. F. Edge, who, as usual, drove an English racer in the Gordon Bennett race this year, has furnished the following data relating to the Napier cars which were specially constructed for the present event. His car uses a four-cylinder motor of the standard Napier type. The motors on the racers are, however, more powerful, and are built for 80 horse-power. At the same time the new motor is exceptionally light, and its weight per horse-power falls below most of the other types, seeing that it weighs but 500 pounds. In the latest form of racing cars every effort has been made to insure that they shall start and stop very quickly, as this is one of the essential points to be observed in racers. Mr. Edge's car has three speeds forward and a reverse.

The friction clutch for connecting the motor to the rear axle works with all-metal surfaces. The chassis is built of steel and is tapered at both ends. The springs are exceedingly long and are carried on the outside of the frame, being brought well toward the ends, as will be observed. In the present car the driver sits very low and the motor differs from that of Col. Mark Mahew's, which is of somewhat similar design, by having Napier multiple port suction valves automatically operated instead of mechanically, as the latter system has been prepared for a four-cylinder racing motor. The latter is exceedingly flexible, enabling the car to run from 20 up to 80 miles an hour without needing to operate the speed-changing device. The racer is provided with Napier high-tension synchronized ignition. It has direct drive from the motor to the rear shaft when running at full speed. The use of chain driving has been discarded for the racing cars, and it is preferred to drive the rear axle by a longitudinal driving shaft provided with a bevel gear. The wheels are 34 inches in diameter and have 5-inch tires on the back and 3.6-inch on the front. The weight of the complete car is 2,118 pounds, which is well under the prescribed limit.

Of the racers we have described so far, the Turcat-Méry (French) and Fiat (Italian), which we illustrated in the preceding number, obtained fourth and eighth and tenth places respectively; while the Mors (French), Pipe (Belgian), obtained the seventh and sixth places in the general classification. The time of the winner—Théry, on a Richard-Brazier machine—was 5 hours, 50 minutes, 8 seconds. The second and third places were captured by German Mercedes cars of the type heretofore illustrated, in 6 hours, 1 minute, 28 seconds, and 6 hours, 46 minutes, 31 seconds. The Turcat-Méry racer covered the course in 6 hours, 48 minutes, 11 seconds, thus finishing but 2 minutes, 20 seconds behind the second Mercedes. The Pipe car's time was 7 hours, 2 minutes, 36 seconds, and that of the Mors, 7 hours, 15 minutes, 3 seconds. The Italian machines finished in 7 hours, 17 minutes, 54 seconds, and 7 hours, 23 minutes, 36 seconds respectively. The length of the course over which the race was run was 348 miles, and the time 5 hours, 50 minutes, 3 seconds.

(To be continued.)

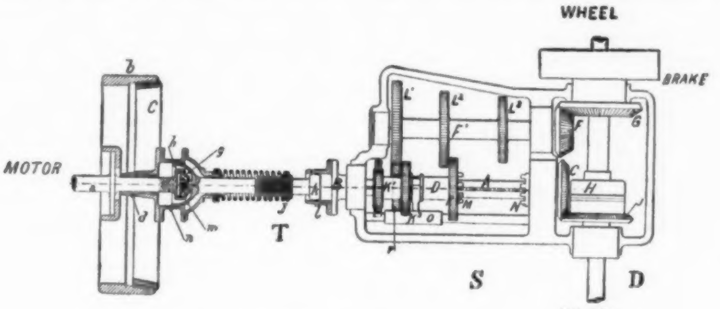


FIG. 4.—THE CLUTCH AND TRANSMISSION GEAR.

THE 100-HORSE-POWER PIPE RACER, WHICH GAINED THE SIXTH PLACE.

LAKE BAIKAL WAR TRAFFIC.

THE conduct of traffic across Lake Baikal last winter must count among the most remarkable of military operations. The ice-breaker ferryboats, something of the pattern of those which ply across the Straits of Mackinaw, have been able to cross the lake but a few weeks of each winter. The length of the ferry until a few months ago was 42 miles. On the average the two boats, one large and one small, have been able to make but three passages in 48 hours, with capacity altogether insufficient for the forwarding of men and supplies of a large army, and this year they made their last winter passage January 27. Meanwhile, by building on the east side of the lake, where the ground is not difficult, a section of the line around the south end of the lake, a harbor (Tanchoi) was reached, which is only about 25 miles from the terminus on the west side of the lake, and to this troops were marched over, and supplies carried in sleighs; while the light railroad laid on the ice, and worked by horses, was opened March 2, when 20 cars were hauled across; later on, some days as many as 220 cars crossed, and by March 14 no less than 1,300 cars had been transferred to the east side. But the railroad was not like one on dry land, or even that over the smooth surface of the Mississippi, on which Milwaukee & St. Paul trains used to cross. Great longitudinal cracks in the ice appeared from time to time, sometimes nearly six feet wide, and the track would be shifted as these were closed. Where they were most frequent a grating of rails and timbers was placed under the track, which had to be watched constantly. When the cars had been mostly transferred and it was thought that the track had been got into pretty firm condition, it was ventured to haul the locomotives over it. An old 30-ton engine sank with its fore wheels, but was raised again. The heavier engines (some 50 tons) were taken apart, the boiler, etc., loaded on two cars, and the frame and running gear hauled on its own wheels. In the course of four days 65 engines were transferred to the east coast. March 26 a wide fissure parallel with the track appeared, the weather moderated, and on the 27th the track was taken up, after 2,313 freight cars, 25 passenger cars and 65 locomotives had been hauled across, together with some 25,000 tons of freight; while 16,000 men had crossed on sleighs.

In April the navigation was open. The two regular ferryboats cannot transfer more than about 1,200 men per day; but the government has impressed nearly all the private steamboats on the lake, which are quite numerous, and with these it should be possible to transfer men and supplies faster than the railroad can bring them. Meanwhile, work is progressing with great energy on the unfinished part of the connecting line around the south end of the lake, over precipitous crystalline rocks, cleft in the most irregular manner by earthquakes. Notwithstanding the difficulties, it is expected to have the line in operation before the end of summer.—Railroad Gazette.

THE USE OF ELECTRIC CHAMBER LOCOMOTIVES.

THE constantly increasing length of mine haulage and the necessity of working thin seams has caused the mine operators and engineers to seek some more economical and better method of haulage than the use of mules as a source of power.

As the conditions vary greatly in different localities, even in different mines, it is a very difficult problem to decide on a general scheme for power service, particularly when the mines have been worked for years and various apparatus and systems have been introduced, all giving more or less satisfaction, and representing an extremely large initial expenditure; the problem is, however, greatly simplified in developing a new territory.

As the D. L. & W. Company has a large number of mines equipped for electric power on many of the gangway roads, the next step was to handle the cars from the branch to the chambers and return. Having the electric power the best method was to handle the cars with an electric locomotive if this could be done without the use of trolley wire in the chambers, as this method is objectionable for the following reasons:

It would be necessary to constantly increase the length of the trolley wire in the chambers as the work progressed; and, furthermore, the locomotive could not work close to the face on account of blasting, which would blow down the trolley wire if it were run in too far; hence, in order to adopt this plan it would be necessary to use rope to pull the loaded cars out of the chamber going to the dip and a rope and headblock to pull the empty cars to the face of these going to the rise.

With this end in view the question was taken up with the Mining Department of the General Electric Company, and after a year or so a locomotive equipped with a cable reel device was installed in the Cayuga Colliery, June, 1902. The locomotive was tested and finally put in actual service at the end of the anthracite strike.

In a short time it was handling the cars, taking them from the foot of the shaft 4,220 feet to a branch and distributing them from there to twelve chambers, ten of these chambers varying in grade from 6 to 17 per cent to the rise, and two about 8½ per cent to the dip.

The locomotive weighed 6½ tons, and was equipped with two 25-horse-power (railway rating) motors. The use of the locomotive in this section was abandoned when the grade of the chambers exceeded 17 per cent, as this proved to be about the limit on which it could safely be used, the danger being that in case the power went off the motorman was likely to set the brake too hard and skid the wheels, causing a runaway.

The locomotive was then taken to another part of the mine and there handled the cars for fourteen chambers during the day and took them to the branch, these chambers going to the dip on a grade varying from 2 to 6 per cent. At night this locomotive tended twelve of the above places. The number of cars per chamber being five one day and six the next.

This locomotive proved the scheme to be successful and other locomotives with reel equipments were ordered.

Two of these were put in operation at the Storrs Mine, June, 1903, and are now taking the cars from a branch and tending forty chambers on a grade varying from 1 to 8 per cent to the rise.

Another locomotive installed in the Dunmore seam at the Bellevue Mine, October, 1903, is tending fifteen chambers, the grade varying from 3 per cent dip to 10 per cent rise. The cars are also taken about 1,000 feet to the foot of the shaft.

Other locomotives of this type will be put in operation shortly. One of these will handle all the cars on two different lifts, the lifts being driven at right angles to a main slope, the grade of which is about 6 per cent. The lifts are practically water level, with the chambers going to the rise 6 per cent and 6 per cent to the dip. The locomotives will go empty from

one lift to the other through a crosscut driven on the grade of the slope. If under these conditions it was not working its full capacity more lifts could be opened up in the same manner.—Mines and Minerals.

MILEAGE AND CAPITALIZATION OF RAILROADS.

The total single-track railway mileage in the United States on June 30, 1903, was 207,977.22 miles, having increased 5,505.37 miles in the year ending on that date. This increase exceeds that of any previous year since 1890. The nineteen States and Territories for which an increase in mileage exceeding 100 miles is shown are Arkansas, California, Georgia, Illinois, Louisiana, Michigan, Minnesota, Mississippi, Missouri, North Carolina, North Dakota, Pennsylvania, Texas, Washington, West Virginia, Wisconsin, Indian Territory, New Mexico, and Oklahoma. Most of the railway mileage of the country, excepting that of street lines, is covered by reports rendered to the Commission by the carriers.

For the year under consideration the operated mileage concerning which substantially complete returns were made was 205,313.54 miles, including 5,902.87 miles of line on which trackage privileges were exercised. The aggregate length of railway mileage, including tracks of all kinds, was 283,821.52 miles, being classified as follows: Single track, 205,313.54 miles; second track, 14,681.03 miles; third track, 1,303.53 miles; fourth track, 963.36 miles; and yard track and sidings, 61,560.06 miles. Thus it appears that there was an increase of 9,626.16 miles in the aggregate length of all tracks, of which 3,339.13 miles, or 34.69 per cent, were due to the extension of yard track and sidings.

The number of railway corporations included in the report was 2,078. Of this number 1,036 maintained operating accounts, 805 being classed as independent operating roads and 231 as subsidiary roads. Of roads operated under lease or some other form of contract, 316 received a fixed money rental, 150 a contingent money rental, and 275 were operated under conditions not readily classified. In the course of the year railway companies owning 11,074.19 miles of line were reorganized, merged, consolidated, etc. For the year 1902 the corresponding item was 7,385.99 miles.

The length of mileage operated by receivers on June 30, 1903, was 1,185.45 miles, showing a decrease of 289.87 miles as compared with the previous year. The number of roads in the hands of receivers was the same as at the close of the previous year, 9 roads having been taken from the hands of receivers and a like number having been placed in charge of the courts.

EQUIPMENT OF RAILROADS.

On June 30, 1903, there were in the service of the railways 43,871 locomotives, the increase being 2,646. As classified, these locomotives were: Passenger, 10,570; freight, 25,444; switching, 7,058. There were also 799 not assigned to any class.

The total number of cars of all classes was 1,753,389, this total having increased 113,204 during the year. The assignment of this rolling stock was, to the passenger service, 38,140 cars; to the freight service, 1,653,782 cars; the remaining 61,467 cars being those employed directly by the railways in their own service. Cars used by the railways that were owned by private companies and firms are not included in this statement. The average number of locomotives per 1,000 miles of line was 214, showing an increase of 8. The average number of cars per 1,000 miles of line was 8,540, showing an increase of 345 as compared with the previous year. The number of passenger-miles per passenger locomotive was 1,978,786, showing an increase of 70,476 miles. The number of ton-miles per freight locomotive was 6,807,981, showing an increase of 141,482 miles as compared with June 30, 1902.

The aggregate number of locomotives and cars in the service of the railways was 1,797,260. Of this number 1,462,259 were fitted with train brakes, indicating an increase during the year of 155,414, and 1,770,558 were fitted with automatic couplers, indicating an increase of 122,028. Practically all locomotives and cars in passenger service had train brakes, and of the 10,570 locomotives in that service, 10,110 were fitted with automatic couplers. Only a few cars in passenger service were without automatic couplers. With respect to freight equipment it appears that most of the freight locomotives had train brakes and 98 per cent of them automatic couplers. Of 1,653,782 cars in freight service on June 30, 1903, 1,352,123 had train brakes and 1,632,330 automatic couplers. In this report there have been continued several summaries, first presented in the report for 1902, to show the general type and efficiency of locomotives and the capacity of freight cars.

In these summaries locomotives are classified under the heads of single-expansion locomotives, four-cylinder compound locomotives, and two-cylinder compound or cross-compound locomotives. Each of these classes of locomotives is further classified according to the number of drivers, and the number of pilot wheels and trailers.

Freight cars are first classified as box cars, flat cars, stock cars, coal cars, tank cars, refrigerator cars, and other cars. The cars in these classes are further distributed among the requisite number of subclasses, the lowest of which, Class I., being for cars having capacities in the 10,000 of pounds; Class II. for cars in the 20,000 of pounds, the other classes successively increasing in the same ratio.

Annealing Bronze.—This process is more particularly employed in the preparation of alloys used in the manufacture of cymbals, gongs, bells, etc. The alloy is naturally brittle, and only acquires the properties essential to the purpose for which it is intended after casting. The instruments are plunged into cold water while red-hot, hammered, reheated, and slowly cooled, when they become soft and sonorous. The alloy of copper and tin has the peculiar property that, whereas steel becomes hard through cooling, this mixture, when cooled suddenly, becomes noticeably softer and more malleable. The alloy is heated to a dark red heat, or, in the case of thin articles, to the melting point of lead, and then plunged in cold water. The alloy may be hammered without splitting or breaking.—Der Metallarbeiter.

CONTEMPORARY ELECTRICAL SCIENCE.*

Measurement of Electric Waves with the Bolometer.—C. Tissot measures the energy of electric waves by means of a bolometer and a galvanometer having a sensitiveness of 5,000 to 6,000 megohms. With such a galvanometer, he is able to discover waves over a distance of 40 km. In his measurements, he operated, as a rule, over a distance of only 2 km., and with a sensitiveness of 2,500 megohms. He then obtained deflections of as much as 250 scale divisions. He made a comparison between the transmission by the direct method—i. e., with the antenna and earth directly connected with the balls of the exciter—and the indirect method—i. e., with the Blondlot or Tesla device. The coherer and the bolometer show a very marked difference of behavior with regard to the two systems. The coherer is more easily influenced by the direct system, whereas the bolometer receives more energy in the case of indirect emission. The phenomena of resonance are very clearly exhibited in the bolometer, especially when an indirect system is employed, which is only slightly damped. The most favorable wave length is nearly four times the length of the antenna. With multiple antennæ, the maximum is still more accentuated. The author gives the following observations with four antennæ:

Capacity	1	2	3	4	5	6
Deflection	16	26	185	69	30	20

The author finally points out that the problem of syntony is chiefly a question of a suitable detector, and that the bolometer is greatly superior to the coherer in this respect.—C. Tissot, Comptes Rendus, November 23, 1903.

Intensity of Sunlight.—The values hitherto obtained for the intensity of sunlight show great discrepancies due to the uncertainty of the photometric units employed, the variation of atmospheric absorption and systematic errors attached to the instruments employed. C. Fabry has endeavored to get consistent and accurate results by a new method, in which the solar intensity is reduced in a known proportion in a way suggested by Bouguer. After traversing a short-focus lens, the beam of sunlight falls upon one of the faces of a Lummer-Brodhun screen. The other face receives a constant illumination of the same color as sunlight. A small incandescent lamp is placed in the focus of a lens, and illuminates the screen through a trough filled with a solution of ammoniacal copper sulphate, thus imparting the necessary whiteness to the light. The ratio of transmission is measured once for all, and the brightness of the lamp is kept rigidly constant. Readings are taken after displacing the lens in the path of the sunlight till equality of illumination is obtained. The measurements were made at Marseilles. The figure for the brightness of the sun in the zenith at its mean distance from the earth, observed from sea level, is 100,000 times the brightness of a decimal candle (1.3 hefner) at 1 meter. One square millimeter of the solar disk emits normally a brightness of 1,800 decimal candles. This figure compares favorably with the 200 candles per square millimeter of the arc. The total energy per candle-power is probably between 0.15 and 0.20 watt. Seeing that the error of the measurements is now reduced to 1 per cent, the author suggests systematic measurements at elevated stations in order to observe variations in the brightness of the sun.—C. Fabry, Comptes Rendus, December 7, 1903.

Luminous Efficiency of Vacuum Tubes.—When Wood measured the temperature of the positive light column directly by means of a bolometer mounted in the tube itself, he found that the luminous gas was only a few degrees above the temperature of the room. Angström found that the light emitted by nitrogen at 0.15 millimeter pressure has the extraordinary luminous efficiency of 90 per cent. These facts have led E. R. Drew to undertake a careful study of the temperature and luminous efficiency of glowing vacuum tubes, on the general lines of Angström's experiments, but using a radiometer instead of a bolometer or thermo-couple on account of its freedom from magnetic disturbance. Owing to the great variation of the efficiency with the diameter of the tube, the author first made a comparison of two tubes of different diameters under identical conditions. He found that a tube 18 millimeters in diameter has about half the efficiency possessed by a tube 9 millimeters in diameter, and the efficiency is always a little less for alternate currents than for direct currents. The luminous efficiency of vacuum tube radiation from air at the pressure of 1 millimeter is approximately 20 per cent. A considerable proportion of this radiation is due to a single line, or narrow group of lines, at wave-length 4.75μ. The author discusses the results from the point of view of the electron theory. The theory that the radiation is due to collisions between charged particles and neutral gas molecules, and that the proportion of high frequency radiation increases with the energy of these collisions, is sufficient to account for the observed facts in all cases where the conditions are well enough known to warrant its application. The temperature of the glowing gas was found to range from 50 to 100 deg. above the ordinary temperature.—E. R. Drew, Phys. Review, November, 1903.

Chemical Effects of Röntgen Rays.—R. Luther and W. A. Uschkoff have discovered a hitherto unsuspected difference in the behavior of light and of X-rays in their action upon a photographic plate. Röntgen rays, even after a very short action upon gelatino-bromide paper, alter its sensitiveness to light, either increasing or diminishing it, whereas a previous exposure to ordinary light does not affect the sensitiveness of the paper for X-rays. In one experiment, the authors exposed a paper to an X-ray object for such a short time that, under ordinary conditions, no image would have appeared on development. They then exposed it to diffuse daylight until the paper turned gray, and then the Röntgen ray image appeared on development black on a gray background. This result led them to try whether under-exposed pictures taken by ordinary light could be brought out by a subsequent treatment with Röntgen rays. In this they were, however, disappointed. When a sensitive plate is exposed first to light and then to X-rays, the effects of the two agents are simply added to each other; but, when the X-rays act first, the final outcome is complicated by something resembling solarization. The density of the final product may then be represented by the formula, $D = R + \dfrac{L}{1 + aR}$ where R is the density of the Röntgen-ray image taken by itself, L that of the light image and a a constant. It is evident that D may be either greater or smaller than R. The authors confine themselves for the present to a statement of the facts, but hope shortly to furnish an explanation.—Luther and Uschkoff, Phys. Zeitschr., December 15, 1903.

Emission of N-Rays by Strained Bodies.—R. Blondlot has found that N-rays are emitted by bodies in a state of strain, such as a bent rod; or bodies in a state of molecular strain, such as tempered steel and glass. On compressing pieces of wood, glass, or india rubber in a press and bringing them near a calcium sulphide screen, they increase its luminosity. A simple experiment is the following: The shutters of a room are closed so as to let in only sufficient light to render the face of a clock situated at 4 yards or 5 yards from the observer faintly visible. A stick is then held in front of the eyes and bent. The clock face is then seen to brighten up, and to become faint again shortly after the force is released. Instead of the rod a piece of glass may be used, bent either by hand or in the apparatus used for demonstrating double refraction by strained glass. Tempered steel exerts a similar action without being bent at all, but only as long as it is tempered. On annealing it, it loses its property. The rays emitted traverse without difficulty a plate of aluminium 1.5 centimeters thick, a plate of wood 3 centimeters thick, black paper, and similar bodies. Steel articles retain the property of emitting N-rays for almost incredible periods of time. Thus a knife found in a Gallo-Roman sepulcher of the Merovingian epoch shows them unmistakably. The author suggests that the mechanism of their emission may be closely connected with that of radium rays. A plate of iron which is permanently bent emits N-rays for a few minutes only, and a block of aluminium shows an even more transitory effect. Torsion produces the same effects as bending.—R. Blondlot, Comptes Rendus, December 7, 1903.

Efficiency of the Nernst Lamp.—L. R. Ingersoll has redetermined the efficiency of the Nernst lamp by Angström's method, in which the total spectrum of the light is dispersed in order to separate out the visible spectrum, and the visible rays are then recombined by means of a cylindrical lens and thrown upon a bolometer or thermopile. The glowers were burnt freely in air, without heaters, on a 100-volt alternating current. A voltmeter and wattmeter across the terminals of the glowers and a rheostat in series enabled the author to keep the voltage or power consumption constant at any desired value. The principal factors in the determination of the efficiency of any glower are its age and the power it consumes. The experiments showed that Nernst glowers are by no means uniform. New glowers show an efficiency of from 4.35 to 4.70 per cent. The efficiency falls rapidly for about the first 20 hours, decreasing to a mean of 4.3 per cent, and varies only slowly after this. Tests of glowers of 40 hours' age and upward gave a mean efficiency of 4.17 per cent. Some very old glowers gave only 3.6 per cent. It is noticeable that after a glower has been burned upward of 20 hours it develops a marked crystalline appearance, and it is probable that the fall in efficiency is due to the greater radiating surface and consequent lower temperature afforded by the crystalline structure. The author adds that if, as is now proposed, the glowers are aged before they are sent out, the deterioration with time may no longer be observable. As regards Hartman's observation, that old glowers show an increase in luminous intensity, the author points out that Hartman kept the current constant rather than the power consumption. As the resistance of the glower increases with age, a constant current means an increased power consumption, and hence a greater emission.—L. R. Ingersoll, Phys. Review, November, 1903.

* Compiled by E. E. Fournier d'Albe in the Electrician.

ENGINEERING NOTES.

Mr. H. A. Ivatt, the locomotive superintendent of the Great Northern Railway, has built from his own designs twenty large express engines of the Atlantic type at the works at Doncaster. The following are the leading dimensions: Boiler, 21 feet long; distance between tube plates, 16 feet; diameter of boiler barrel, 5 feet 6 inches; heating surface, 2,500 square feet; four wheels coupled, 6 feet 8 inches diameter; cylinders, 18¾ inches by 24 inches; total wheel base of engine and tender, 48 feet 6 inches; total length engine and tender over all, 58 feet; weight in working order, 112 tons. These locomotives have been specially built for the purpose of working the East Coast Scotch traffic, and will be capable of running the Scotch expresses with 350 tons from King's Cross to Doncaster without a stop at a speed of 60 miles an hour. For this purpose water troughs have been laid at several points to enable the engines to take up water.

There are three quartz-mining districts in the Transvaal. The Lydenburg district was discovered in 1876; the products for 1898 from four companies, operating 135 stamps, was valued at £392,378. The De Kaap gold fields were discovered in 1884, and in 1898 seven companies with 200 stamps produced gold valued at £314,792. By far the most important district is the famous Witwatersrand (White Waters Range), of Johannesburg, consisting of almost a continuous outcropping of over 30 miles in length, passing through the city of Johannesburg and extending about half that distance on either side. The veins consist of practically parallel beds of quartz-pebble conglomerate, impregnated with gold. These beds are known in South Africa as "reefs," equivalent to "ledges" or "lodes" in America. The first openings were made along the outcrop and followed the dip of the vein, which averages 35 degrees, usually being somewhat steeper at the surface and flattening as it goes down. In 1898 the output of 77 companies operating stamp batteries produced gold to the value of £15,141,376, the total number of stamps in use being 4,765, while in 1899 5,762 stamps were in use.—J. S. Lane in Mines and Minerals.

Many arguments have been advanced in recent years in regard to the subject of drums vs. reels for hoisting. It is not the purpose of the writer to say which system is the better, but to point out the advantages and disadvantages of each. The drum system is today more in use than the reel system. This is true especially in the northern part of Michigan, in what is called the "Copper Range." Some of the world's largest hoists are to be found in the neighborhood of Calumet. Here are drums of 36 feet diameter, capable of holding 8,000 feet of rope and hoisting at the "lightning" speed of 4,000 feet a minute. The drums are of three distinct classes: First, the single and double parallel; second, single and double cone; third, composite, which is a combination of the parallel and cone types. While reel hoists have numerous advantages, yet they are not employed for depths greater than about 3,000 feet, as the weight of the rope becomes then equal to, if not more than, the rest of the load. For deeper shafts other means must be resorted to. Here is where the "composite" drum, before described, comes into successful use, some of these being successfully operated in shafts 6,000 feet deep.—F. F. Coleman in Mines and Minerals.

Santa Clara County in California began oiling roads in 1892, and now has about seventy miles of such highways. The results have been, according to the State Bureau of Public Highways, on the whole highly satisfactory. In the first stages of the experimenting with oil sprinkling there were strenuous objections by some of the people to this method of improving the highways. The chief grievance was the fact that when the oil was first applied it rendered the roads disagreeable to travel upon and had a tendency to soil vehicles and clothing. This, however, proved to be only a temporary trouble, as a few days, when the oil had been properly worked in and the surface smoothed and packed by thorough rolling, sufficed to harden the surface and keep it clean. It was soon realized that the inconvenience caused by the first application of oil was not nearly so great as was caused by the first application of gravel. In the latter case it requires nearly a year for the road to become packed and smooth, while with oil the time required to put it in readiness for easy and dustless travel is only a few days. Oil has the advantage over water in the fact that where applied there is absolutely no dust, and where the roadbed is properly prepared there is practically no mud during the rainy season. The cost per mile of watering the valley roads of Santa Clara County has averaged about $87 per season, exclusive of the cost of water, expenditures for water-wagons, repairs, etc., and with that added, the cost per mile per annum has been about $123. The cost of oiling a mile of road the first season is about $90, for the second season about $50, with a decreasing expense each season following. This estimate includes the entire expense of oiling, and shows a saving of water of $33 per mile the first year and $73 per mile the second year, a saving in expense which is pretty sure to appeal strongly to the taxpayers. In applying the oil, Glover's road-oiling wagon and other wagons, with tank and sprinkler attached, have been used. From 100 to 400 barrels a mile have been used on the first application of oil to the road-bed, depending to some extent upon the width oiled, ordinarily about twelve feet. The famous "Alameda," between San Jose and Santa Clara, is oiled to a width of sixty feet. The oil is heated by steam to a temperature of 300 degrees at a cost of eight cents a barrel, the expansion resulting being about 3 per cent. The quantity used per mile is estimated after heating. Bakersfield oil is used, of a specific gravity of 14 to 17 degrees, costing 90 cents per barrel and upward, according to the distance to be hauled from the railroad station.—New York Evening Post.

ELECTRICAL NOTES.

The chief statistician of the Department of Manufactures in the Bureau of the Census has issued a preliminary report on the telephone systems of the United States of America for the year 1902. Space will not permit us to give full particulars of this in this issue, but we can present a few items which will be of some interest. There are 4,151 systems in use, with 4,350,486 miles of single wire, and 2,315,297 telephones of all kinds. These represent a total number of subscribers 2,137,256, with 10,361 public exchanges, 7,883 private exchanges, and 10,842 manual switchboards. The magneto system still predominates with 10,005, as compared with 837 common battery systems. The number of talks make up some remarkable figures, totaling 5,070,555,345, and of these local exchanges dealt with 4,949,850,491, and long distance and toll were accountable for 120,704,854. The total number of salaried officials and clerks was 14,124, and of wage earners, linesmen, etc., 64,628.

For interurban service, conclusive evidence of the value of electric traction on railways is continually forthcoming. The New York elevated lines are now entirely operated by electricity, the conversion having occupied two years, and from results, comparing the working of the lines under the old and new conditions, some remarkable figures are obtainable. The number of passengers carried during the year ending February, 1904, was 273,133,242, an increase of 37,318,852 over the preceding year. The total car mileage for the same period was 60,730,337, an increase of 12,870,859, or, expressed in percentages, 15.85 and 26.9 per cent respectively. Such figures should impress the railway companies of this country operating suburban trains by steam. Attention has frequently been called to the overcrowding of early and late trains running in and out of the metropolis, and to the ready solution of the difficulty offered by electrification; but, doubtless, railway managers are keeping record of the results of trains operated electrically before coming to a decision. The above will afford some food for reflection.

In an article appearing in a German contemporary H. Passauer states that the storage battery locomotive is specially useful in switch yards where a trolley line would be difficult and expensive. Compared with a steam locomotive it has the advantage of being always ready for service, and its cost of operation is smaller if the locomotive is used at irregular and longer intervals. The high weight of the batteries is an advantage, since a considerable weight is necessary for adhesion. The author describes the first storage battery locomotive which has been built for such purposes for the Prussian State railways. The battery consists of 200 cells, with a capacity of 184 ampere hours, if discharged in two hours. It is charged once a day. Twenty cells are placed in a wooden box, which is covered with an acid-proof insulating coating. These wooden boxes are well insulated from each other and from the locomotive by means of porcelain rolls. For charging the battery at 110 volts, the cells are connected in five groups, each of 40 cells in parallel. After the charge is completed the cells are all connected in series, so that an average discharge voltage of 360 to 410 is available. The charge takes place with constant current and with resistance regulation. The controller is arranged for series parallel control. The total weight of the locomotive is 59,000 pounds, of which 22,000 pounds is the weight of the battery, and 9,500 pounds that of the other electric apparatus.

The Electric Transformer.—The one thing which underlies the adoption of the alternating current and the development of modern electrical transmission is the transformer. Its principle, its functions, and its purpose are so well known that they require no elementary exposition. It may be of interest, however, to point out a very simple mechanical analogue in the transmission of mechanical power by a belt. If a power is to be transmitted from an engine shaft 8 or 10 inches in diameter to a second shaft parallel with it, a belt which could be placed directly on the two shafts would serve to transmit energy if they were of proper relative diameters, and would also effect any change in speed which might be desired. If the power to be transmitted were small, a horse-power or so, nothing further would be needed; but if it were several hundred horse-power, the size of belt for transmitting would be so large as to make it impracticable. In order that a large power may be transmitted by a small belt it is necessary to increase the diameter of the pulleys and the speed of the belt. If the pulleys were of sufficiently large diameter, the pull upon the belt would be so small that a mere thread could transmit a hundred horse-power. Such an arrangement is mechanically impracticable, although the electrical analogue does not suffer the same limitations. When mechanical power is transmitted, the higher the belt speed, the less the size of the belt required for transmitting a given horse-power; likewise in an electric circuit, the higher the voltage of the transmission, the less need be the size of conductor necessary. By means of pulleys of suitable diameter the desired relation between speed and belt tension is secured in one case, and by means of transformers with suitable windings the desired relation between current and pressure is obtained for the electric transmission. Through the intervention of the transformer, transmission pressures are usually not controlled or limited either by the voltage of the generator or the voltage of the distribution current. A generator may supply current directly to the circuits for lighting, or it may be removed many miles, and the current actually transmitted may be only one-hundredth part of that either in the generator or in the lamps.—Charles F. Scott, in Cassier's Magazine.

SCIENCE NOTES.

Caliche is a Spanish name, used variously to denote several kinds of mineral deposit. In South America it is applied to deposits of crude soda niter (saltpeter). In Arizona the caliche is a calcareous deposit formed beneath the surface sand or soil and in some districts extends over large areas. It is also found in some portions of southern and lower California, in New Mexico, and in the desert region of western Australia. It generally conforms more closely to the surface contour of the ground than to any stratification of the debris that may be present. In some localities the caliche is gold bearing, the occurrence being similar to gold-bearing conglomerates. The formation of this calcareous deposit beneath the surface is supposed to be due to the precipitation of calcium carbonate from upward-flowing solutions, induced by the rapid evaporation of those arid regions. The infrequent rains leach the calcium carbonate that may be deposited in the upper layers. Calcareous travertine is deposited on the surface from calcareous springs and is different from caliche.—Mining and Scientific Press.

The word bamboo suggests to most Americans a faithful fishing rod or a dainty fan. To the Japanese and Chinese, who are the most practical agriculturists in the world, it is as indispensable as the white pine to the American farmer. They are not only dependent upon it for much of their building material, but make their ropes, mats, kitchen utensils, and innumerable other articles out of it. There are many varieties of the bamboo plant, from the species which is woven into mats to the tall bamboo tree which the Chinaman uses for the mast of his large boat. One variety is cultivated as a vegetable, and the young shoots eaten like asparagus, or they may be salted, pickled, or preserved. The rapidity of growth of the bamboo is perhaps its most wonderful characteristic. There are actual records of a bamboo growing 3 feet in a single day, or at the rate of 1½ inches an hour. Varieties of bamboo are found everywhere in Japan, even where there are heavy falls of snow in winter. It is a popular misconception that bamboos grow only in the tropics. Japan is a land of bamboos, and yet where these plants grow it is not so warm in winter as it is in California. Some of these varieties could be grown commercially in the United States.—David G. Fairchild in the National Geographic Magazine.

Hungarian dentists and chemists claim to have discovered a valuable local anæsthetic, an alkaloid, "nervocidine," the hydrochloride of which is stated to have properties similar to cocaine, but to produce a much more lasting anæsthesia. The base is obtained from an Indian plant, "gasu basu," the properties of the leaves of which were first discovered by Dalma, who successfully employed them in painful pulpitis with such good results that he reported that the drug might displace arsenic for dental purposes. B. von Feny-vessy has investigated the properties of the alkaloidal hydrochloride, as prepared by Dalma, which is a yellow, amorphous, hygroscopic powder, readily soluble in water. It produces marked anæsthesia of the cornea in a 0.1 or 0.2 per cent solution, which is very persistent, and a 0.1 per cent solution brushed on the mucous membrane of the cheek also gives marked anæsthesia. Stronger solutions exceeding 0.5 per cent produce irritation of the cornea, and a 2 per cent solution causes ulcerative keratitis in dogs and rabbits, which lasts ten days, during which period the anæsthesia also lasts. It does not appear to produce anæsthesia by subcutaneous injection. Its general effect is that of a paralyzing poison. Although its anæsthetic effect is much more prolonged than that of cocaine, the length of time necessary before this effect supervenes, the irritation caused by the drug, and the toxic symptoms it produces do not point to the probability of its being of general service, except perhaps in dental practice.

A correspondent of the Times describing the excavations at Naukratis, the one privileged colony of Greeks in the Nile Delta under the Saite Pharaohs, says:

Evidence accumulates that the town underwent at least one sack of very drastic sort not long after its foundation. Structures, which are not of later date than the earlier part of the fifth century B.C., have earlier ones underlying them and separated by a thick belt of *debris*. Probably the deep trench found by Mr. Petrie in the precinct of Apollo, full of fragments of early vases, was cut when the time came to efface the marks of this cataclysm. Who sacked Naukratis? One thinks naturally of the Persian invasion and the maltreatment of the Delta by Cambyses. Herodotus says nothing of Cambyses in connection with this particular city; but there is no reason why he should have done so. A Persian sack was ancient history by the time Herodotus came to visit Naukratis, and all trace of it had probably been obliterated. It may be remarked in this connection that of his visit in the latter part of the fifth century B.C. a possible relic has come to light in the recent excavations—namely, the base of a painted vase inscribed "Herodotou." This vase was found within the Hellenion precinct; and, seeing the comparative rarity of the name and the

coincidence of the date of the vase, as judged by its fabric and the lettering of the dedication, with the probable epoch of the Halicarnassian's visit, one may be allowed to read on this offering an autograph of the father of history.

TRADE NOTES AND RECIPES.

Method of Hardening Gypsum and Rendering it Weather-proof.—Gypsum possesses only a moderate degree of strength even after complete hardening, and pieces are very liable to be broken off. Various methods have been tried, with a view to removing this defect and increasing the hardness of gypsum. Of these methods, that of Wachsmuth, for hardening articles made of gypsum and rendering them weatherproof, deserves special notice. All methods of hardening articles made of gypsum have this in common: the gypsum is first deprived of its moisture, and then immersed in a solution of certain salts, such as alum, green vitriol, etc. Articles treated by the methods hitherto in vogue certainly acquire a considerable amount of hardness, but are no more capable of resistance to the effects of water than crude gypsum. Now the object of Wachsmuth's process is not merely to harden the gypsum, but to transform it on the surface into insoluble combinations. The process is as follows: The article is first put into the required shape by mechanical means, and then deprived of its moisture by heating to 100 deg. to 150 deg. C. It is then plunged into a heated solution of barium hydrate, in which it is allowed to remain for a longer or shorter time, according to its strength. When this part of the process is complete, the article is smoothed by grinding, etc., and then placed in a solution of about ten per cent of oxalic acid in water. In a few hours it is taken out, dried, and polished. It then possesses a hardness surpassing that of marble, and is impervious to the action of water. Nor does the polish sustain any injury from contact with water, whereas gypsum articles hardened by the usual methods lose their polish after a few minutes' immersion in water. Articles treated by the method described have the natural color of gypsum, but it is possible to add a color to the gypsum during the hardening process. This is done by plunging the gypsum, after it has been deprived of its moisture, and before the treatment with the barium solution, into a solution of a colored metallic sulphate, such as iron, copper, or chrome sulphate, or into a solution of some coloring matter. Pigments soluble in the barium or oxalic acid solutions may also be added to the latter.—Der Techniker.

Coating Mirrors with Silver.—Make 1,000 parts of a 10 per cent solution of silver nitrate in distilled water. Add to it ammonia water, drop by drop, until the precipitate at first thrown down is nearly, but not quite redissolved. Let stand for an hour, filter, and to the filtrate add enough distilled water to make 1,500 parts. This is the silvering solution. To make the reducing solution proceed as follows: In a flask of sufficient capacity, dissolve 25 parts of sodium and potassium tartrate in 1,000 parts of distilled water and boil the solution for 4 minutes. While boiling add 4 parts of silver nitrate dissolved in 100 parts of distilled water, let the solution come to a boil again, then remove from the fire, let stand for a few minutes, filter and make the filtrate up to 1,500 parts by the addition of distilled water. Keep the solutions in separate vessels until required for use, and then use equal parts of each. To make the operation a success, the following precautions are necessary: The surface of the glass to be silvered must be chemically clean. To effect this immerse in strong nitric or hydrochloric acid for a few moments, remove with wooden forceps and rinse under flowing water. Immerse a second time, carefully refraining from touching the glass with the hands, in liquor potassæ or sodæ for a few moments, remove and rinse under flowing water. Finally immerse in 95 per cent alcohol and let remain until you are ready to use it. Above all, never touch the surface to be silvered with your fingers after it has been cleaned. If you do, you must go over the work again, or risk a black, ugly spot on your finished work. The least touch of the fingers, in warm weather especially, will leave sufficient sodium chloride, so delicate is the reaction, to decompose a portion of the silver and ammonium nitrate and cause the stain. When these solutions are mixed and exposed to the direct sunlight, or to heat, reduction of the metal commences and takes place in every direction and is deposited on the walls and bottom of the container, but mostly and best on the surface of the fluid. For this reason it is best and most economical to arrange the glass to be silvered so that its surface just touches and is wet by the liquid. With small mirrors this is very easily effected, but with larger ones it is not so readily done, unless you have large flat containers, of the size of the mirror you wish to make. In the absence of these a dam of wax or other material should be built around the edges of the glass and the mixed solutions poured into the reservoir thus formed. The whole apparatus should then be exposed to the direct sunlight. The reduction progresses most rapidly at a temperature of about 120. The liquid turns at first to an inky black, and this gradually clears. The liquid should be removed, however, before it becomes clear, as otherwise a redissolving action soon sets up. On removing the glass from the solution it should be rinsed in running water and stood on edge on bibulous paper, a brick, or some absorbing material and allowed to dry thoroughly. Afterward the back or silver surface should be coated with a cement or varnish to protect it.—National Druggist.

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